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RANGE PASTURE STUDIES IN SOUTHERN ALBERTA AND SASKATCHEWAN.

BY

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Contribution of the Division of Forage Plants, Central Experimental Farm, Ottawa, Canada.

INTRODUCTION.

IN southern Alberta and south-western Saskatchewan there are certain areas of considerable extent that are unsuited for cultivation, due to conditions of climate, topography or soil. Lack of soil moisture due to scanty precipitation and a high rate of evaporation is the limiting factor over most of the area, while in certain localities roughness of topography or unfavourable soil conditions make cultivation impracticable. Attempts to produce cultivated crops in these areas have been generally unsuccessful and it is now generally recognized that the native vegetation constitutes the best crop which can be obtained from them.

During the early settlement of Western Canada most of the prairie sections were used at one time or another for the production of livestock under range conditions. With the advent of more settlers came the change to cultivation and crop production, especially of the cereal grains. At one time it appeared that all of the West might be so transformed and that the ranching industry would give way to grain farming. However, the natural conditions mentioned above halted the march of the plough and assured the range livestock industry of a permanent place in Western agriculture.

At present there are about 12 million acres of native range pastures in Southern Alberta and Saskatchewan and an estimated four million acres of abandoned farm lands, most of which will revert probably to their original state. In addition, there are several million acres of marginal land, the correct utilization of which has not yet been decided upon, and whose owners will probably continue to fluctuate between dry land farming and ranching, influenced largely by climatic cycles and the relative price of wheat and livestock. During years of above-normal precipitation even the driest portions of the prairie region will yield fair crops and it is usually during such years that much unwise settlement occurs.

GENERAL.

1. *Location and topography of range lands.*

Most of the range lands are located on the short-grass prairie area or what is known as the brown to light brown soil zone. This area is bounded on the south by the International boundary and on the east, north and west approximately by a line drawn from slightly west of Estevan north-west to Moose Jaw, and on to Macklin, then south-west keeping slightly east of Olds and Calgary and then south to Lethbridge and on to the Montana border. The short-grass prairie comprises nearly 34 million acres, about half of which is used as range pastures.

The greater part of this region consists of more or less rolling country which rises from about 1,800 feet on its eastern border to over 3,000 feet at its western limits. In places the prairie is deeply cut by " coulees," steep banked, eroded watercourses which are dry during most of the year. Erosion is illustrated best in the " badlands," rough areas in which constant erosion maintains a soil surface which is either sparsely vegetated or bare. This area is drained by one main system, the Saskatchewan river and its tributaries which flow into the Hudson Bay, and by several minor streams such as the Milk river which flows south-east to the Missouri. The Cypress Hills constitute the principal break in this great stretch of prairie. This ridge, which rises to about 4,800 feet at its highest point, lies a short distance south of the main line of the Canadian Pacific Railway and extends approximately 70 miles east and 50 miles west of the Alberta-Saskatchewan boundary. The top of this ridge is plateau-like and shows no signs of glaciation. To the west of the prairies lie the Foothills which in turn give way to the Rocky mountains. There are large range areas in the Foothills. Owing to the roughness of the topography and the short frost free period most of this area is not suited to the growing of grain crops. It has, however, a good cover of native vegetation and a considerable acreage is devoted to forage crops production.

2. *Climate.*

The climate of the short-grass prairies is characterized by low precipitation, high rate of evaporation, high and frequent winds, great extremes of temperature and abundant sunshine. Precipitation occurs chiefly in the form of rain, nearly 75 per cent of which falls during the growing season. Many of the rain showers are too light to be of any real value to plant life, and much of the heavier rains is lost by run-off. Moisture conditions are rendered even more unfavourable by the fact that the variation in annual precipitation is greatest in the driest areas. Data concerning the precipitation and evaporation at certain prairie points are presented in Table I.

Table 1. Precipitation and evaporation records for some prairie points.

Place	Average Precipitation			Evaporation–Precipitation Ratio with Precipitation as 100	Precipitation	
	Rain	Snow	Total		Wettest year	Driest year
Swift Current, Sask. . .	10·60	4·12	14·72	190	24·55	9·17
Medicine Hat, Alta. . .	9·93	3·26	13·19	–	25·28	6·39
Manyberries, Alta. . .	–	–	11·31	285	–	–
Lethbridge, Alta. . .	11·69	4·27	15·96	160	28·05	7·62

Temperatures, like precipitation, fluctuate widely in the short-grass area. Hot west or southwest winds during midsummer are frequent and their effects on plant life are often serious. In winter these warm winds or " chinooks " remove the snow cover, usually several times each winter, thus permitting grazing by livestock during the winter months.

3. *Soil Types.*

The soils of the short-grass prairie region are mostly of glacial origin. They are medium brown to light brown in colour and mostly fine in texture and compact in

structure. In most of the upland soils a layer of salt concentration, commonly called " hard-pan," occurs at depths varying from a few inches to 2 feet or more. This semi-impermeable layer, having a high content of calcium carbonate, marks the depth to which soil moisture penetrates normally. In some areas are found numerous shallow depressions, called "blow-outs" or "burn-outs," roughly circular in shape and varying from 2 to 50 feet or more in diameter. These are usually either bare or very sparsely vegetated. Their surface soil is very compact in nature and almost impermeable to water.

Physically, the soils of the region range from nearly pure sand to heavy clays. In general, fine sand and silt loams are the most common types.

The soils of the area tend to be rather low in organic matter, but are reasonably well supplied with the mineral plant nutrients. Most are more or less alkaline, but not often to the extent of inhibiting plant growth.

The light brown soils occur in the driest portion of the short-grass prairie zone, and are characterized generally by very fine texture, well-marked " hard-pan," and rather low fertility. The " run-off " of precipitation on this soil type is high.

The brown soils are found over most of the short-grass prairie area and tend to be more open in texture and more fertile than the light brown soils. The " hard-pan " layer is usually found at a greater depth and often is not well developed.

The chemical composition of some typical prairie soils is presented in the following tables. All analyses are based on composite samples taken at a depth of 0 to 6·66 inches. All plant nutrients are given on a percentage basis.

Table 2. Composition of typical light brown soils at Manyberries, Alberta.

Type	Nitrogen	Phosphoric acid		Potassium		Lime	Magnesium	pH.
		Total	Available	Total	Available			
(1) Typical upland soil. Sandy loam, mostly fine sand with some silt and a little clay	0·150	0·147	0·045	0·473	0·028	0·588	0·921	7·7
(2) Gumbo clay flat. Grey, silty loam of the nature of gumbo, refractory when dry	0·095	0·144	0·023	0·651	0·021	1·792	1·026	8·2
(3) " Blow-out " area. Grey silty clay loam, less silt and fine sand than (2). Fairly friable when dry	0·110	0·118	0·028	0·540	0·016	0·798	0·439	7·9

These light brown soils are all low in nitrogen and humus-forming material. The sandy loam, which is the common type, is the most fertile of the three and is considered to be sufficiently well supplied with potassium, lime and magnesium but rather deficient in phosphorus. The gumbo clay soil is lower than the loam in nitrogen, available phosphorus and potassium, but is well supplied with lime and magnesium. The soil from the " blow-out " area is similar to the gumbo clay, but is very low in available potassium.

Table 3. Composition of typical brown soils, Saskatchewan and Alberta.

Place	Type	Nitrogen	Phosphoric acid	Potassium	Lime	Magnesium
Swift Current, Sask.	Fine sandy loam	0·169	0·109	1·482	–	–
Swift Current, Sask.	Silt loam (fine sand and silt)	0·223	0·141	1·697	–	–
Swift Current, Sask.	Clay loam	0·231	0·113	1·793	–	–
Hanna, Alberta ..	Sandy loam, fine sand ..	0·153	0·103	1·290	0·924	0·232
Hanna, Alberta ..	Silt loam	0·174	0·126	1·390	0·952	0·547
Hanna, Alberta ..	Clay loam	0·113	0·151	–	1·148	0·812

The soils from these two sections of the brown soil zone show a general conformity in composition, with the Swift Current samples slightly higher in nitrogen. These soils are fairly well supplied with the essential plant foods other than phosphorus which is no higher than in the light brown soils from Manyberries. In general, the silt and clay loams are better supplied with plant nutrients than are the sandier soils.

Most of the short-grass prairie soils are sufficiently fertile to produce good fields of vegetation in years of adequate rainfall. Precipitation, not soil fertility, is the chief limiting factor in plant growth.

4. *Land Utilization.*

Before the beginning of the present century nearly all of the short-grass prairie area was used for grazing purposes. There was considerable open range, and a number of large ranching outfits operated in southern Saskatchewan and Alberta. Livestock were free to graze over large areas, there was an abundance of pasturage, operating costs were relatively low and little thought was given to pasture studies.

With the advent of the dry land farmer, conditions were greatly changed. The better parts of the prairies soon became settled and in this western invasion many sections were brought under cultivation that were not at all suited to grain growing. The result was that subsequently several million of acres were abandoned and the fields left to become grown to weeds. Other rather extensive sections, as for instance those adjacent to Lethbridge, Brooks, and Vauxhall, were brought under irrigation and there a more intensive type of farming is practised. The problem of land utilization is still an urgent one and is at present receiving much attention.

With the settlement of the better portions of the prairies the free range era came to an end. Ranchers were forced to buy or lease grazing lands and to fence their pastures. Additional watering places had to be developed and the cost of operation was greatly increased. Following the year 1916 the range lands experienced a long succession of dry years. Many of the pastures became overgrazed and weedy. To make matters worse, prices of livestock dropped to very low levels in post-war years. As a result, the ranching industry became unprofitable and some of the stockmen were forced out of business.

The stockmen themselves were the first to realize that there was an urgent need for investigational and research work pertaining to grazing practices, range management and management of livestock on the range. In 1926, acting upon requests of stockmen's associations, the Dominion Government appointed a commission to investigate conditions and to submit definite recommendations.

RANGE PASTURE INVESTIGATIONS AT MANYBERRIES, ALBERTA.

During 1926 a survey of the range areas of Saskatchewan and Alberta was made by Mr. L. B. Thomson and the senior author, on behalf of the Dominion Experimental Farms Branch. Over one hundred and fifty ranches were visited, the purpose being to become acquainted with the ranchers themselves and with the conditions under which they worked.

During 1927 the Dominion Range Experimental Station, the first of its kind in Canada, had its inception. A site was selected near Manyberries, in south-eastern Alberta in the heart of the ranching country on an area typical of the range lands of the drier portions of the short-grass prairie. At present the station lands include about 18,000 acres of native range and about 65 acres of cultivated land. The range is fenced off into 4 large fields of about 3,500 acres each, and a group of 9 smaller fields which total 1,400 acres. In addition there is a winter pasture of 1,200 acres and also horse pastures, etc. About 200 acres of typical range have been fenced and set aside for such projects as require protection from grazing.

Most of the cultivated land is irrigated by means of water stored in a reservoir made by building an earthen dam across a "coulee." Alfalfa, oats and other forage crops are grown both for experimental purposes and for winter feed. About 10 acres of land are used for fodder production tests under strictly dry land conditions. A herd of some 500 Hereford cattle are used for the various grazing experiments during the spring, summer and fall. Only about 150 are kept during the winter. Stock-watering places have been developed on all the fields. These are mostly small reservoirs made by building earthen dams across the "coulees" which are so numerous in this area.

Buildings include a main office and laboratory, housing accommodation, barns, store-houses, corrals, etc.

NATURE OF INVESTIGATIONS.

The principal projects conducted at the Manyberries Station are the following:—

(1) Pasture studies.

(2) Forage crop production—including the development and testing of varieties of feed crops suited to conditions in the range country as grown (*a*) under irrigation, as practised by ranchers, and (*b*) under dry land conditions.

(3) The management of livestock on the range including the handling, weighing, etc. of livestock, the development of watering places, preservation of fence posts, building of fences, corrals, etc., the testing of different feeds as maintenance rations for the winter months, etc.

In this paper we are concerned only with those investigations that have to do with range pasture studies.

PASTURE STUDIES.

Our projects dealing with the native range vegetation fall under the following general heads:

Fundamental plant studies.	Range management.
Range improvement.	Grazing capacity and production.

FUNDAMENTAL PLANT STUDIES.

These comprise investigations into the nature of the native range vegetation, and are of prime importance as a basis for the applied studies in range management, etc.

(1) *Plant collection and identification.*—The flora of the short-grass prairie has been studied and the principal plant species collected, identified and placed in the station herbarium. Many specimens have also been collected from the Cypress Hills and Foothills areas. Each species is collected from various localities and types

of habitat, and notes are made concerning its distribution and relative abundance. Photographs are taken of the principal species. About six hundred species of flowering plants have been collected and identified.

The short-grass prairie zone is dominated by low-growing perennial grasses. Non-grass forms comprise 25 per cent or less of the total vegetative cover.

The dominant grass species are: *Stipa comata* Trin. and Rupr. (long-awned speargrass), *Agropyron smithii* Rydb. (western wheatgrass), *Bouteloua gracilis* (H.B.K.) Lag. (blue grama grass), *Koeleria cristata* (L.) Pers. (Junegrass), *Poa secunda* Presl. (Sandberg bluegrass), and *Carex filifolia* Nutt. (thread-leaved sedge or nigger-wool). These six species constitute about 90 per cent of the total grass cover.

Grasses of secondary importance include: *Calamagrostis montanensis* Scribn. (plains reedgrass), *Calamovilfa longifolia* (Hook.) Scribn. (sandgrass), *Deschampsia caespitosa* (L.) Beauv. (marsh hairgrass), *Distichlis stricta* (Torr) Rydb. (alkaligrass), *Elymus canadensis* L. (Canada wild-rye), *Hordeum jubatum* L. (wild barley), *Muhlenbergia cuspidata* (Torr.) Rydb. (plains muhlenbergia), *Poa nevadensis* Vasey and *P. palustris* L. (bluegrasses), *Spartina gracilis* Trin. (alkali cord-grass), *Stipa viridula* Trin. (short-awned speargrass), *Carex rostrata* Stokes. (slough sedge), *C. stenophylla* Wahl. (dwarf sedge), *Eleocharis palustris* (L.) R. and S. (wire-grass), and *Juncus balticus* Engelm. (dwarf rush).

Other herbaceous species include: *Achillea millefolium* L. (yarrow), *Allium textile* Nels. and MacBr. (wild onion), *Antennaria microphylla* Rydb. (cats'-paw) *Artemisia frigida* and *A. ludoviciana* var. *gnaphalodes* Nutt. (dwarf sagebrush), *Atriplex nuttallii* S. Wats. (salt sage), *Ctenophyllum pectinatum* (Hook) Rydb. (straggling white pea), *Eurotia lanata* (Pursh) Moe. (silver sage), *Gutierrezia sarothrae* (Pursh) Britton and Rusby (brown-weed), *Oxytropis gracilis* (A.Nels.) K. Schum. (yellow loco), *Opuntia polyacantha* Haw. (cactus), *Phlox hoodii* Richards (dwarf phlox), *Selaginella densa* Rydb. (little clubmoss), *Solidago missouriensis* Nutt. (prairie goldenrod), *Sphaeralcea coccinea* Nutt. Rydb. (globe mallow), *Thermopsis rhombifolia* (Nutt.) Richards (prairie bean), *Zygadenus venenosus* Wats. (death camas).

The principal shrubby forms are: *Artemisia cana* Pursh. (sagebrush), *Elaeagnus commutata* Bernh. (silver-berry), *Rosa* spp. (wild rose), *Salix* spp. (willows), *Sarcobatus vermiculatus* (Hook.) Torr. (greasewood), *Sheperdia argentea* Nutt. (bull-berry), *Symphoricarpos occidentalis* Hook. (snow-berry).

The principal plant families of the area are the Gramineae, Compositae, Leguminosae, Cyperaceae and Chenopodiaceae. Non-flowering species are not abundant, the only one of outstanding importance being *Selaginella densa*. Fungi and mosses play only a very minor role under the dry conditions which prevail in the short grass zone.

The vegetation of the Cypress Hills includes a lower transitional area and an upper zone which consists of (*a*) a mixed-grass prairie quite different from the short-grass type, and (*b*) a forest zone dominated by coniferous trees.

The mixed-grass area is dominated by a number of grass species including *Festuca scabrella* Torr. (rough fescue), *F. idahoensis* Elmer. (bluebunch fescue), *Danthonia intermedia* Vasey (timber oat-grass), *D. californica* Bolander (California oatgrass), *Agropyron subsecundum* (Link.) Hitchc. (bearded wheatgrass), *Stipa viridula*, and *S. comata* var. *intermedia*, *Koeleria cristata*, *Calamagrostis canadensis* (Michx) Beauv. (marsh reedgrass), and *Avena hookeri* Scribn. (Hooker's oatgrass). Sedges include *Carex rostrata* and other *Carex* spp.

The principal forbs* are *Artemisia frigida*, *Geranium viscosissimum* F. and M. (wild geranium), *Lupinus macounii* Rydb. (wild blue lupin), *Hedysarum americanum* (Michx) Britton (purple hedysarum), *Lithospermum canescens* (Michx) Lehm. (puccoun), and species of *Erigeron*, *Potentilla* and *Astragalus*.

* The term *forb* is used to denote herbs other than grasses.

The principal shrubby form is *Dasiphora fruticosa* (L.) Rydb., with lesser amounts of *Rosa* spp., *Symphoricarpos*, *Salix* spp., etc.

The Forest Zone is dominated by *Pinus contorta* var. *latifolia* Engelm. (lodgepole pine), with lesser amounts of *Picea glauca* Voss. (white spruce), and *Populus tremuloides* Michx. (aspen).

The principal grass is *Calamagrostis rubescens* Buckl. (pine-grass).

Grasses of secondary importance include *Elymus* spp. (wild-rye grasses) and *Glyceria* spp. (manna-grasses).

Other common herbs include *Arctostaphylos Uva-ursi* Spreng. (bearberry), *Lathyrus ochroleucous* Hook. (white vetchling), and *Vicia americana* (blue vetch).

The principal shrubs include *Amelanchier alnifolia* Nutt. (Saskatoon), *Juniperus sibirica* Burgsd. (dwarf juniper), *Salix* spp. (willows) and *Spiraea lucida* Dougl. (white spiraea).

(2) *Morphology*.—A study has been made of the vegetative characters of the native grasses of the short-grass prairie with a view to establishing a system of identification based on these characters. Such knowledge is very valuable in range pasture studies, especially during the drier years when few grass culms are produced. A study is made of the characters of such parts as the bud-shoot, sheath, leaf-blade, collar, ligule and auricles. In these studies, large numbers of individual plants from various habitats are examined. At present about 45 grass species, including some half dozen species from the Cypress Hills, have been studied and described. A preliminary key has been prepared, which will be revised as the work progresses.

(3) *Growth development*.—A study has been made each year of the growth development of the principal native species. Such factors as the time of first growth in spring, rate and extent of leaf growth, time and extent of culm production and flowering, time and extent of seed production, date of curing, etc., have been determined yearly. Detailed studies involving measurements of numbers of individual plants are made on specific sites at Manyberries. In addition, general observations are made on the station ranges and also in other regions such as the Cypress Hills, where detailed studies are not possible.

The general object of this project is to obtain a complete and accurate picture of the life-cycle of each of the more important native range plants in order to understand more fully their reaction to various grazing practices.

The principal grass species are very well adapted to withstand the rigorous climatic conditions and to utilize efficiently the scanty precipitation. Most of the chief grasses begin growth early in April and develop rapidly during the months of May and June when moisture conditions are usually fairly favourable and temperatures not excessively high. A certain amount of seed is produced usually before the customary drought of midsummer begins. Curing occurs during July and August of most years. The principal exception to the above type of growth development is found in *Bouteloua gracilis* which begins growth nearly a month later than the other dominant grasses, and continues to grow rather slowly all summer. This species possesses to a marked degree the ability to withstand periods of drought and quickly resume growth whenever soil moisture becomes available again.

(4) *Palatability*.—Numerous observations have been made at Manyberries and adjacent areas to determine the extent to which the various native range species are grazed (*a*) by different classes of livestock, (*b*) in different growth stages, (*c*) at different seasons of the year, and (*d*) under different methods and intensities of grazing. All these factors affect the extent to which any plant is eaten, and render more complicated the task of estimating the relative palatability of the different species.

In general, the principal native grasses of the short-grass prairie zone are palatable to all classes of livestock during the whole year. Some of the secondary grasses are palatable to a lesser extent, often being grazed during part of the year only. Many of the principal forbs and shrubs are not so palatable as the grasses,

and some are eaten only slightly or not at all. As a rule, sheep will eat more of these forms than will cattle or horses.

The relative palatability to cattle of some of the principal native species of the short-grass prairie zone is presented in the following table. The groupings must be regarded as approximate only and quite subject to variation under special conditions. Under rigorous winter conditions stock will eat many plants which they would leave untouched during the summer. The table is based on year-long grazing, i.e. a species, to be classed as "eaten readily," must be grazed readily during all the year, and not merely in one particular season.

Table 4. Relative palatability to cattle of principal native species.

Eaten readily.	*Eaten fairly readily.*	*Eaten slightly.*	*Not eaten.*
Agropyron smithii.	*Calamovilfa longifolia.*	*Artemisia frigida.*	*Antennaria microphylla.*
Bouteloua gracilis.	*Distichlis stricta.*	*Artemisia cana.*	*Gutierrezia sarothrae.*
Carex filifolia.	*Salsola pestifer.*	*Rosa spp.*	*Opuntia polycantha.*
Eleocharis palustris.		*Sarcobatus vermiculatus.*	*Phlox hoodii.*
Koeleria cristata.		*Sphaeralcea coccinea.*	*Selaginella densa.*
Poa secunda.			*Symphoricarpos occidentalis.*
Stipa comata.			
Atriplex nuttallii.			
Eurotia lanata.			

(5) *Chemical Composition.*—Many samples of the principal native species have been collected each year for chemical analysis at the Manyberries Station. Some samples have been collected also from other range areas such as the Cypress Hills and Alberta Foothills. The herbage is cut to approximately the height that a cow would graze it, i.e. one to several inches from the ground, depending on the nature of the plant. Most herbs are grazed closely, while only the young succulent shoots of shrubby forms are eaten. A sample consists of the current year's growth of one species in one growth stage. Most samples weigh about three-quarters of a pound, air-dried weight.

The aim of these investigations is to determine the approximate nutritive value to livestock of each of the principal native forage species in different growth stages and growing under different conditions ; also to find what, if any, are the deficiencies in the range forage.

The average chemical composition of the five principal grasses, collected in a number of different growth stages, is presented in Table 5. These five species comprise *Stipa comata, Bouteloua gracilis, Agropyron smithii, Koeleria cristata* and *Poa secunda.* The difference in chemical composition between these species is not very great and they can, therefore, be averaged in this way :

Table 5. Average chemical composition of five principal grass species collected in different growth stages.

Stage	Protein	Fibre	CHO	Fat	Total Ash	CaO	P_2O_5
Leaf	18·00	24·23	46·17	2·53	9·33	0·561	0·602
Flower	9·61	32·33	48·95	2·41	6·80	0·400	0·414
Seed	7·06	33·54	50·70	2·32	6·46	0·419	0·291
Cured	5·00	33·02	51·76	1·81	8·52	0·530	0·187
After winter exposure..	4·18	34·82	50·79	1·26	9·00	0·512	0·178

It will be observed that, while in the early leaf stage, these grasses have a high protein content and contain sufficient calcium and phosphorus to meet the requirements of range livestock. As the plants mature, become cured and are exposed to winter conditions the percentage of protein and phosphorus drops to a very marked degree. After the grass has passed the flowering stage there is a serious deficiency in phosphorus content and the percentage of protein is less than half that of the early leafage. There does not appear to be any significant decrease in calcium content.

(6) *Poisonous Plants.*—The principal species of the short-grass prairie which are poisonous to livestock have been collected and identified, and their distribution and relative abundance studied. The most important of these is *Zygadenus venenosus* (death camas) which causes rather heavy losses among sheep on the range. *Oxytropis gracilis* (yellow loco-weed) is quite common, but appears to do little harm to livestock. In the western United States this weed causes heavy losses among horses. Losses from poisonous plants are undoubtedly linked with the over-grazed condition of ranges, and at present most of our range pastures still contain sufficient desirable forage to prevent the eating of harmful amounts of poisonous weeds. Control of death camas can be accomplished by intelligent herding of range sheep, since this weed occurs usually in rather well-defined patches.

In the Alberta foothills, serious losses among range cattle are caused by *Delphinium brownii* (tall larkspur). This weed is quite common on certain low timber ranges and is eaten fairly readily by cattle, especially during the spring and early summer months. At present the only practical remedy seems to consist in keeping cattle away from badly infested portions of range at that time of the year.

(7) *Plant succession.*—Studies are being made of plant succession on the short-grass prairie under the influence of various climatic, soil and biotic factors. Changes occurring in the vegetative cover are recorded by means of various types of quadrats and transects.

The climatic climax of the area seems to consist of a grassland type dominated by five grasses: *Stipa comata*, *Agropyron smithii*, *Bouteloua gracilis*, *Koeleria cristata* and *Poa secunda*; and one sedge, *Carex filifolia*. The influence of climatic cycles, soil type and grazing practices on the relative abundance of these dominant species is being studied.

Natural revegetation of abandoned fields furnishes some interesting and economically important examples of secondary successions. On a typical abandoned field the plant cover for the first two or three years consists almost entirely of the "tumble-weeds," *Salsola pestifer* (Russian thistle) and *Sisymbrium altissimum* (tumble-mustard). These annuals are replaced by short-lived perennials, particularly *Artemisia frigida*. The principal grass species at this stage is often *Hordeum jubatum*. Gradually these species are replaced by long-lived perennials, chiefly the dominant native grasses; and eventually the area develops a grass cover similar to that which it possessed prior to cultivation. The length of time required for this process varies greatly with conditions of climate, soil and the biotic factors involved; and anywhere from six to twenty years or more may be required.

(8) *The Relationship of Soil Types and Plant Species.*—Soil samples have been collected from the principal plant communities of the short-grass prairie, and also from special types such as alkaline areas, sand dunes, etc. For each sampling, a narrow trench is dug to a depth of several feet and samples collected from each of the different soil horizons. Further investigations are necessary before definite results can be given on this work.

(9) *The Relationship of Environment to Plant Growth.*—A detailed study at the Manyberries Station is in progress to determine how the various climatic and soil factors influence plant growth. On two sites representing the two principal vegetative and soil types of the area, numerous plants of each of the principal native species are selected, marked and studied individually during the growing season. The

vegetative growth, culm development, flowering, seed production and seed viability of each plant is recorded. On the same sites the climatic and soil factors are studied. Air and soil temperatures, wind velocity, evaporation rate and soil moisture are recorded. Air temperatures are determined among the grass clumps, while soil temperatures are taken at a depth of four inches below the surface. Wind mileage is obtained by means of an anemometer placed with its vanes at the level of the vegetation. The rate of evaporation is measured by means of porous cup atmometers placed among the grass. Soil moisture samples are taken weekly at a depth of 2 to 6 inches and occasionally at depths of 6 to 12 inches and 12 to 18 inches also. This deeper sampling is particularly valuable after heavy rains to determine the maximum penetration of the water. Data concerning precipitation, hours of sunshine, air temperature in the shade and evaporation from a free water surface are all obtained from a standard weather station located close to the two sites.

This study will be continued for a number of years to determine the reaction of vegetation to various sets of climatic and soil conditions.

RANGE MANAGEMENT.

The present practice on the majority of the range lands of the short-grass prairie is to graze the major portion of the range continuously during the spring, summer and fall months, reserving a smaller portion for winter use. This latter area, being protected from grazing during the growing season of each year, usually maintains a productive grass cover fairly free from unpalatable weed types. The larger portion, however, which is grazed usually from about April 1 to the middle of November, often becomes badly depleted, with a thin grass cover and numerous weeds. Sometimes a measure of renovation can be obtained by using a certain portion of the range in winter for several years, and then turning it over for summer grazing and using a portion of the summer field for winter. However, considerable shelter for livestock is an important characteristic of a winter pasture, and often there is only one portion of a range that meets this requirement.

At the Manyberries Station experiments are being conducted to determine whether or not some systematic grazing rotation can be developed which will increase the productivity of any particular piece of range which is grazed during the " summer" period (April to November).

The principal project in this connexion consists of the testing of a system of deferred and rotational grazing with cattle. The rotation being practised involves the division of the grazing unit into three equal portions, i.e. fields A, B and C. The grazing season is then divided into three equal parts, designated as spring, midsummer and fall. The fields are grazed in the following order during a six-year period.

Period	*1st year*	*2nd year*	*3rd year*	*4th year*	*5th year*	*6th year*
Spring	B	A	C	A	C	B
Midsummer	A	B	A	C	B	C
Fall	C	C	B	B	A	A

At the end of a six-year period each field has received the same grazing treatment, i.e. each field has been protected from early spring grazing during four years out of the six, and has been protected during the growing season for two years out of the six. Thus the native forage plants are given a considerable measure of spring protection, and also, during two years out of each six, an opportunity to mature and shed their seed before being exposed to grazing. It will be noted that the two years of growing season protection for each field come consecutively, in order that any seedlings which may result from the first year's seed crop may have protection during their first year of growth, which time is very critical on dry range areas.

This rotation is being tested at the rate of 20, 30 and 40 acres per cow during the " summer " grazing period. Continuous grazing for the same period at the same rates is being conducted on adjacent check fields.

The reaction of the vegetation to these various systems and intensities of grazing is being studied by means of : (*a*) charted metre quadrats, (*b*) listed metre quadrats, (*c*) listed perquadrats, (*d*) yield tests, and (*e*) systematic general observations.

(*a*) The vegetation on charted quadrats is mapped to scale by means of a pantograph. The number of plants of each species on the quadrat is recorded, together with the location of each individual plant and the area occupied by it.

(*b*) The vegetation on the list quadrats is recorded with the aid of a square metre frame divided by cross-rods into 100 equal parts. The number of plants of each species and the total area occupied by each species are recorded, and a few plants of special importance on each quadrat are mapped freehand on cross-section paper.

(*c*) The perquadrats vary in size from 4 to 100 square metres and are used chiefly to study shrubs or other large and conspicuous plants. Counts are made of the particular species under observation and only general notes are made on the remaining vegetation. Certain individual plants or the boundaries of plant communities are often mapped to scale on cross-section paper.

Practically all the metre and perquadrats established at the Manyberries Station are of the permanent type. They are definitely marked with iron stakes and their exact location described carefully. The soil type, slope, altitude, exposure, etc. of each quadrat is recorded. Large numbers of these permanent quadrats have been established on representative areas on the various grazed fields. They are recharted every 3 or 4 years and additional notes taken on them annually. In this way, an accurate measure is obtained of any changes which occur in the vegetative cover. The quadrats are marked in such a way as not to interfere with normal grazing by the cattle.

(*d*) Yield tests are obtained by clipping the current season's growth from areas varying in size from 1 to 6 square yards, depending on the number of replicates, nature of the study, etc. Hand-clipping with grass shears has been found to be the most satisfactory method in this short-grass area.

(*e*) Systematic general observations are made on each of the grazed fields several times during the year, but particularly at the close of the grazing season. By riding slowly back and forth across a field, covering a strip of fairly uniform width each time, a trained observer can obtain valuable data as to the comparative condition of the various fields, particularly with respect to their carry-over of old grass at the end of the grazing season.

Grazing practices which are being tested also on clipped plots on the experimental area include : (*a*) deferred and rotational grazing, as practised on the grazed fields, (*b*) deferred and rotational grazing using only two fields instead of three, and (*c*) continuous grazing. The reaction of the vegetation to these clipping practices is studied by the same means as were outlined for the grazing studies.

Due to the number and complexity of the factors involved and to the rather slow rate of vegetative change in semi-arid areas, studies in range management usually require considerable time before definite results can be obtained.

The Manyberries grazing and clipping experiments have not yet shown definitely whether any of the grazing rotations being tested are sufficiently superior to continuous grazing to warrant general adoption. Certain points which have been determined already are as follows :

(1) Early spring grazing is much more harmful to the native range vegetation than is midsummer, fall or winter grazing.

(2) Twenty acres per cow for the grazing period April 1 to November 15 inclusive is not enough in the Manyberries district, regardless of whether the grazing be rotational or continuous.

(3) Range cattle tend to be restless in small fields of 100 acres or less and do an excessive amount of trampling and wandering along the fence lines.

(4) On large fields which are not overstocked, cattle practise a sort of natural rotation by their habit of grazing any one area only partially at one time.

(5) To maintain the vegetative cover of a range pasture in good condition there should be a carry-over of old grass at the end of each year's period of grazing use. This carry-over should be not less than 25 per cent of the season's growth.

RANGE IMPROVEMENT.

This includes projects dealing with (*a*) artificial reseeding of depleted range lands, (*b*) artificial reseeding of abandoned fields, (*c*) the effects of surface cultivation on the native vegetative cover, (*d*) the effects of fertilizers on the native vegetative cover, and (*e*) the eradication of pasture weeds.

(*a*) Reseeding on range lands at the Manyberries Station has been tried using different methods, dates and rates of seeding. Many species of grasses and legumes have been tested. On the whole, results have not been promising. In some cases a fair stand was obtained, but almost always the seedlings failed to survive competition with the native grasses. The chief exception was crested wheat grass (*Agropyron cristatum*) which has become established in some cases even among a fair cover of native grass.

In considering the results obtained at Manyberries, it must be remembered that most of the areas sown, while over-grazed, still retained a fair cover of the native grasses, and therefore did not offer an ideal environment for young seedlings.

In general, it would seem that artificial reseeding will give beneficial results only when done on depleted range areas containing very few plants of the native grass species. Furthermore, species must be sown which are able to germinate, grow and produce seed under the climatic, soil and biotic factors which prevail on the area.

(*b*) Reseeding of fields that have been brought under cultivation, cropped for a few years and then abandoned has been quite successful. Crested wheat grass (*Agropyron cristatum*) has proved to be the best species we have for this purpose. Best results are obtained when the seeding is done while the fields are in the annual weed stage, i.e. covered chiefly with Russian thistle, tumbling mustard and other annual species. The crested wheat grass seed should be drilled in among the weeds, using preferably a double disk grain drill, or sown broadcast among the weeds and the field then single disked in order to cover the seed lightly. Seeding should be done either in the fall or early in the spring and the seed should be sown not deeper than half an inch.

Several fields in the Manyberries district have been reseeded with good results. When a good stand is obtained on an abandoned field it is much more productive than the native sod.

(*c*) Experiments have been conducted to determine the effects of surface cultivation on the vegetative cover of range lands. The principal method consisted of disking with an ordinary farm disk at different dates and rates.

On upland areas seed production and yield of native fodder was increased slightly by both single and double disking. Double disking has increased the yield of forage by 25 per cent. Further studies are in progress to determine the effects of this treatment on plant succession, natural reseeding, etc. On certain overgrazed areas disking may be of benefit in breaking up the dense mats of *Selaginella densa* which cover so much of the ground and which make natural reseeding very difficult. On lowland gumbo clay areas, disking was destructive to the vegetation and decreased the yield of forage slightly.

(*d*) The effects of top-dressing with both commercial fertilizers and barnyard manure have been tested. The application of commercial fertilizers, particularly those containing nitrogen and phosphorus, increased both the yield and the nutritive value of the native fodder. Ammonium phosphate gave the most consistent increases in yield. Applications of this fertilizer at the rate of 150 pounds per acre gave

increases in yield varying from 5 to 50 per cent depending on the amount of rainfall received. However, in years of average rainfall the increase in fodder production was not sufficient to offset the cost of the fertilizer used.

Applications of barnyard manure at about 15 tons per acre have given greatly increased yields of native forage. Plots manured at this rate in 1928 are still producing over twice as much fodder as are adjacent untreated plots. On the average, the application of barnyard manure has increased the yield of forage by over 100 per cent. The manure not only adds fertilizer to the soil, but it keeps the soil at a lower temperature and lowers the rate of evaporation.

In general, it would seem that the application of commercial fertilizers is warranted only where the potential productivity of the land is fairly high. In areas of limited rainfall such treatment of range pastures is not sound economically. Manuring, however, gives greatly increased yields, and should be practicable on small pasture areas close to the supply of the fertilizer.

(*e*) Eradication of certain pasture weeds has been attempted by means of cutting, burning and application of herbicides.

Repeated cutting of *Artemisia cana* (sagebrush) greatly weakens the plants and kills them eventually, but the labour involved renders the scheme unsound from a practical point of view. A study is being made of the effects of burning both on certain weed species and also on the native grass cover.

Experiments were conducted on *Zygadenus venenosus* (death camas) and *Opuntia polyacantha* (cactus), using various commercial herbicides and also solutions of arsenic pentoxide. Eradication of death camas accompanied by a minimum of damage to the grass cover was accomplished by a single spraying of an arsenic pentoxide solution consisting of one part of the chemical to 32 parts of water by weight. Spraying when the flowers were budding proved most effective. Certain commercial herbicides did a little less damage to the grass cover, but did not eradicate the death camas completely.

Cactus proved very resistant to all herbicides. Complete eradication was obtained only after two applications of a double strength solution of arsenic pentoxide which destroyed the grass cover as well as the cactus.

Eradication by herbicides of particularly injurious pasture weeds such as death camas would appear to be a practical measure where the plants are confined to definite patches.

FORAGE PRODUCTION AND GRAZING CAPACITY STUDIES.

These include (*a*) a study of the productiveness of range lands under total protection from grazing and also under various systems and intensities of grazing, (*b*) the relative productivity of different native species, (*c*) the determination of the grazing capacity of range lands.

(*a*) The production of native forage under protection is determined by clipping fenced plots which are located on several typical parts of the range. The average yields obtained from plots clipped every year and every other year for the period 1931 to 1935 inclusive, expressed in terms of pounds per acre of air-dried forage were 223 and 283 respectively.

The production of forage on grazed areas is determined chiefly on fields that are grazed under a deferred and rotational system. The native forage is harvested from plots established on fields that are grazed during the autumn months only. The old growth is removed from these plots previously and the current year's growth only is included in the yield test. The average yields of air-dried forage per acre obtained from 5 replicates for each of three plant types were as follows :—

Dominant species	Sub-dominants	Average yield for two years in lb. per acre
Stipa comata	*Bouteloua gracilis, Koeleria cristata*	184
Bouteloua gracilis	*Stipa comata, Koeleria cristata, Agropyron smithii*	106
Agropyron smithii	*Poa* sp., *Koeleria cristata, Bouteloua gracilis*	236

The vegetative types dominated by *Agropyron smithii* and *Stipa comata* considerably outyield that dominated by *Bouteloua gracilis.* This is to be expected since *Bouteloua gracilis* is the dominant species only on areas having a shallow soil or where conditions are otherwise unfavourable for plant growth. *Stipa* and *Agropyron* species are usually dominant on areas having a deeper soil and more favourable moisture conditions.

(*b*) The relative productivity of different species is studied by clipping the grass from specific unit areas. A record is kept of the areas clipped for each species and the yield of each species is dried and weighed and the yield per unit area calculated. This study continued over a number of years will enable us to determine the relative productivity of our principal grasses and to arrive at a yield coefficient for each species.

(*c*) The grazing capacity of range lands at Manyberries Station is being tested under actual grazing by cattle as described under range management. Grazing at the rate of 20, 30, and 40 acres per cow for the " summer " period is being tested.

The data obtained to date on this project indicate that not less than 35 acres per cow is needed for the grazing period, April 1 to November 15, while an additional 15 acres is needed for the winter season, making a total annual grazing capacity of 50 acres per cow. The grazing capacity of ranges in other portions of the short-grass prairie will vary from this figure in accordance with climatic, soil and biotic factors involved.

SEED PRODUCTION IN SCANIA, SWEDEN.

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[Translated from Swedish by R. Peter Jones.]

THAT good results can be obtained from seed production in Scania is seen from Table 1, which shows the seed yield per hectare on the average of the different 5-year periods from 1920–1934 and also for comparison the average yield during the years 1926–1933 in Denmark according to " Dansk Frøavl," No. 20, 1935.

Table 1. Average seed yield per hectare.

	1920/1924	1925/1929	1930/1934	1920/1934	1926/1933 in Denmark
Trifolium pratense ..	383	305	368	355	304
T. hybridum ..	—	389	335	380	273
T. repens	—	487	350	375	207
Phleum pratense ..	483	493	502	493	384
Dactylis glomerata ..	449	468	528	491	521
Festuca pratensis ..	535	502	435	499	569
Lolium perenne ..	591	825	882	784	799
L. multiflorum ..	850	857	841	848	994
Bromus arvensis ..	1059	1071	1095	1075	820
Mangels, Barres ..	1440	1851	2312	1900	1490
Mangels, Eckendorf	1364	1304	1767	1508	—
Swedes	1603	1634	1613	1619	1050
Turnips	1275	1407	1434	1396	800

The average figures cited show that with the exception of cocksfoot (*Dactylis glomerata*) meadow fescue (*Festuca pratensis*), perennial and Italian ryegrass (*Lolium perenne* and *L. multiflorum*) the seed yield per unit of area in Scania has been as large as, and even larger than that in Denmark.

In past years the extent of seed production varied greatly. During the last 5-year period it has in general been more stabilized. Table 2 shows the annual average yield of different species of seed during the period 1931–1935.

Table 2. Annual average yield of different species. 1931–1935.

Species	Average area, hectares 1931–1935	Average yield, per hectare, kg. 1920–1934	Seed crop produced. dt. (= 100 kg.)
Seed of grassland legumes :			
Trifolium pratense	435	355	1544·3
T. hybridum	51	380	193·8
T. repens	37	375	138·8
Total ..	523		1876·9

* Translated from the article : " Fröodlingen inom Skåne." [Seed production in Scania.] Skånes Fröodlingsförening, 1911–1936. pp. 35–57. Malmö, 1936.

Table 2. Annual average yield of different species. 1931–1935.—*con.*

Species	Average area, hectares 1931–1935	Average yield, per hectare, kg. 1920–1934	Seed crop produced. dt. (= 100 kg.)
Seed of meadow grasses :			
Phleum pratense	439	490	2151·1
Dactylis glomerata	363	490	1778·7
Festuca pratensis	100	500	500·0
Lolium perenne	143	785	1122·6
L. multiflorum	35	850	297·5
Bromus arvensis	47	1075	507·3
Total ..	1127		6357·2
Seed of roots :			
Sugar beet	311	2000	6220·0
Mangels, Barres and fodder sugar beet	233	1900	4427·0
Swedes	164	1620	2656·8
Turnips	155	1400	2164·0
	863		15467·8

The seed yield during 1935 was, however, considerably larger than the average figures cited indicate, and is sufficient to meet Sweden's requirements, with the exception of grassland legumes, timothy, and perennial ryegrass. (See Table 3).

Table 3. Seed crop of meadow plants and roots produced in Scania in 1935.

	Area in ha.	Yield in kg. per ha.	Yield in dt.
Seed of grassland legumes :			
Trifolium pratense ..	700	400	2800
T. repens	50	400	200
T. hybridum and Medicago lupulina	71	450	315
Total ..	821		
Seed of meadow grasses :			
Phleum pratense	400	500	2000
Dactylis glomerata	450	600	2700
Festuca pratensis	145	700	1015
Lolium perenne	300	900	2700
L. multiflorum	62	1400	868
Bromus arvensis	80	800	64
Festuca rubra	40	200	80
Poa pratensis	2	700	14
P. trivialis	13	670	87
P. serotina	12	580	70
Total ..	1504		

Table 3. Seed crop of meadow plants and roots produced in Scania in 1935.—*con.*

	Area in ha.	Yield in kg. per ha.	Yield in dt.
Seed of roots :			
Sugar beet	350	2200	7700
Mangels and fodder sugar beet	500	1900	9500
Swedes	270	1000	2700
Turnips	160	900	1440
Total ..	1280		

The area utilized for seed production in Scania in 1935 comprised 3,895 ha., as follows : seed of roots 1,280 ha. ; grassland legumes 821 ha. ; various meadow grasses 1,504 ha. ; carrot, caraway, mustard, fodder marrow kale, flax and different species of garden plants 290 ha.

GRASSLAND LEGUMES.

Red clover (*Trifolium pratense*) has in past years not been grown for seed in Scania to any great extent. Recently there has been a considerable increase in the seed production area of this species.

From Table 1 it is seen that quite good yields can be obtained from the red clover seed plots in Scania : the average yield was 355 kg. per ha. for the period 1920–1934. (According to Professor H. Witte, on the average of 211 plots during the period 1910–1919 the average yield was 400 kg. per ha.). For comparison it may be mentioned that according to Dr. Trotzig the average yield of red clover seed for the whole of Sweden during the years 1921–1931 amounted to 282 kg. per ha. The average yield in Scania was therefore according to the figures cited about 72 kg. more per ha. than for the country as a whole.

During certain years when weather conditions were favourable during seed setting the seed yield in Scania was considerably larger than the average figures quoted. In 1935 some plots yielded as much as 600 kg. seed per ha. In 1935 the quantity of red clover seed produced in Scania was about 280 tons. Sweden's requirements amount to approximately 5,000 tons. Dr. N. Sylvén at Svalöv has shown that the strains which at present have the highest cultivation value in Scania are the old local strains Karaby, Spannarps and Harrie. An increased seed production of red clover is to be recommended and with it an improved seed production technique. The haphazard method of putting up for seed a portion of the hay ley should be discarded, as a rational control of weeds is most difficult with this method of cultivation. Sowing in adequately spaced drills makes it very much easier to obtain red clover seed leys free from weeds.

The seed production of alsike clover (*Trifolium hybridum*) in Scania is at the present time very restricted. According to Table 2 it amounted during the period 1931–1935 on an average to approximately 50 ha. per annum. During recent years the average seed yield has been 380 kg. per ha. ; this exceeds the yield obtained in Denmark per unit of area by a little more than 100 kg. (According to Professor Witte, the average yield in Scania before 1919 was 350 kg. per ha.). An increased seed production of alsike clover is also to be recommended. To protect indigenous seed production, during recent years import of seed from abroad has been forbidden almost completely. Import is not necessary, as Sweden, in addition to supplying her own needs, exports annually quite considerable quantities of seed of alsike.

White clover (*Trifolium repens*) has during the last 5-year period on an average been grown for seed only on about 37 ha. per annum. This is too small an area

considering the great value of this species in permanent pasture leys. Through the advance in rational pasture cultivation, at the present time very large quantities—approximately 80 tons—of white clover seed are used, which are generally for the most part imported. The yield of the white clover seed plots certainly fluctuates and is dependent on the weather during the summer ; hitherto it has amounted on the average to about 375 kg. per ha. With present prices of white clover seed this cultivation should be remunerative. For seed production the Danish strain Morsø should be employed until the Swedish plant breeding stations succeed in producing a strain which has a higher cultivation value and which is better suited to Swedish climatic conditions.

MEADOW GRASSES.

Timothy (*Phleum pratense*). Timothy is the chief hay grass in Sweden and the consumption of timothy seed is considerable—approximately 6,000 tons. Seed production of this species is not conducted on a large scale in Scania. On the average of the last 5-year period about 440 ha. were used for this purpose. The average yield during the last 15 years in Scania was approximately 490 kg. per ha. and exceeded the average yield in Denmark by a little more than 100 kg. (During the period 1910–1919 the average yield in Scania, according to Professor Witte, was 480 kg. per ha.). Considerable quantitities of timothy seed are produced in central Sweden but nevertheless this cultivation can be further increased in Scania without risk of over-production, as Swedish timothy seed is at a premium abroad. An improved cultivation technique should be carried out in seed production of timothy ; the distance between the drills should be slightly greater than that recommended hitherto, so that the weeds *Matricaria inodora* and *Chrysanthemum leucanthemum* can be more easily controlled. The strains " Gloria " and " Kämpe " constitute good material for seed production of timothy.

Cocksfoot (*Dactylis glomerata*). On the average of the 5-year period 1931–1935 the cocksfoot seed production plots in Scania comprised about 365 ha. and the seed yield on the average of the last 15 years was approximately 490 kg. per ha. About the same yield per unit of area is cited also from Denmark. (During the period 1910–1919 the average yield in Scania was 465 kg. per ha., according to Professor Witte). In 1935 cocksfoot was grown for seed on 450 ha. and a crop of nearly 270 tons was obtained. An increase in seed production of cocksfoot is not necessary, as less cocksfoot seed should be used in Swedish hay leys, and other species such as timothy and meadow fescue should be sown instead.

Meadow fescue (*Festuca pratensis*). In contrast to cocksfoot, seed production of meadow fescue should be increased. On the average during the last five years seed production of meadow fescue has comprised annually about 100 ha. The average yield during the last 15-year period was 500 kg. per ha. and was therefore somewhat lower than in Denmark. (According to Professor Witte, the average yield was 580 kg. per ha. prior to 1919). As meadow fescue is an excellent hay grass, and is also extensively used in permanent pasture leys, the area of this species should be increased considerably to obviate altogether the importation of seed. During the year 1935 seed production of meadow fescue in Scania comprised an area of about 145 ha., and a yield of approximately 700 kg. per ha. was obtained. The total seed crop that year was estimated to be a little more than 100 tons. The annual seed requirement is approximately the same quantity as the 1935 crop. As such a high yield per hectare as that obtained in 1935 cannot be counted on generally, an increase in the area of this species is necessary.

Perennial ryegrass (*Lolium perenne*) has been grown for seed in Scania for many years ; the Victoria strain in particular has a very high cultivation value. The consumption of perennial ryegrass has increased in the course of the years, the reason being that this grass is very extensively used in permanent grazing leys and in lawns in parks and gardens. In Scania the seed production area during the last

5-year period comprised on the average about 145 ha. per annum. and the average yield during the years 1920–1934 was 785 kg. per ha. Approximately the same yield per unit of area is recorded also from Denmark. (According to Professor Witte, the average yield before 1919 was 840 kg. per ha.). There is no risk of over-production as seed of the Victoria strain can be profitably exported.

Italian ryegrass (*Lolium multiflorum*) and field brome grass (*Bromus arvensis*) have during the last 5-year period been grown for seed on about 35 and 50 ha. respectively. The average yield per ha. for Italian ryegrass during the period 1920–1934 was 850 kg., and for field brome grass 1,075 kg. (According to Professor Witte, before 1919 the average yield of Italian ryegrass was 900 kg., and of field brome grass 1,065 kg., per ha.). Seed production of these species should be increased to meet Swedish requirements ; these amount in the case of Italian ryegrass to 75 tons and in that of field brome grass to about 120 tons. During 1935 the seed yield of Italian ryegrass was very good, and was computed to be not less than 87 tons. During that year seed production was sufficient to meet the country's requirements.

OTHER GRASS SPECIES.

Festuca rubra, Poa pratensis, P. trivialis and *P. serotina* have been grown for seed on small areas in Scania during recent years. The seed plots have, however, not been able to satisfy Sweden's own needs ; this applies particularly to *Poa pratensis*, one of the most outstanding pasture grasses in Sweden, so that seed production of this species should be extended considerably.

ROOTS.

Sugar Beet. Seed production has been practised in Scania during the last 25 years and almost exclusively on behalf of the Swedish Sugar Co., Ltd. Sweden's present requirement of seed for sowing is approximately 1,000 tons. To meet this requirement with home-grown seed an increase of 70 hectares in the seed production area is necessary.

Mangels, swedes and turnips. Seed production of fodder roots has been carried on throughout the past 25 years. Since 1930 considerable areas have been utilized for this purpose, and during the last 6 years Sweden has been almost self-supporting and has found it necessary to import only a very small amount of seed.

The seed area of *mangels* during the last 5 years was about 230 ha. per annum, and the average yield during the years 1920–1934 amounted to 1,900 kg. per ha. for Barres. (According to Professor Witte, the average yield during the years 1910–1919 was 1,780 kg. per ha.). Yields vary considerably from year to year depending on weather conditions and attacks by disease. Thus in 1921 the approximate average yield of Barres was 900 kg. per ha. and in 1922 1,300 kg. per ha. : during the period 1920–1924 it was about 1,440 hg., from 1925–1929 1,851 kg., and during the 5-year period 1930–1934 about 2,312 kg. per ha. The average annual yield of Eckendorf during the last 15 years was approximately 1,500 kg. per ha. In Denmark the seed yield of Barres is much lower than in Scania—about 1,500 kg. per ha.

Seed production of *swedes* has also been conducted on quite a large scale : on the average of the last 5-year period the area has been approximately 165 hectares and the average annual yield per hectare for the years 1920–1934 was about 1,620 kg. (On the average of the years 1910–1919 the average yield in Scania, according to Professor Witte, was only 1,170 kg. per ha.). The seed yield has of course fluctuated from year to year; during the last 16 years it has varied from 1,000 to 2,000 kg. per ha. The average yield during 1935 was only about 1,000 kg. per ha. owing partly to weather conditions and partly to attacks by insect pests. Sweden's annual requirement of swede seed is about 150 to 200 tons.

During the years 1929–1933 the seed production area of *turnips* was relatively large, and particularly during 1930, when it comprised 320 hectares. During 1934

seed production showed a marked decrease owing to the fact that the firms held large stocks. Only some 50 hectares were used that year for seed production. During 1935 the area was almost normal, but owing to the poor crop obtained—about 900 kg. per ha.—there is a danger that the amount of turnip seed produced in Scania may not be sufficient for Sweden's requirements, which amount at present to about 150–200 tons. On the average of the last 5 years the annual turnip seed area in Scania was about 155 hectares and the average annual yield per hectare during the years 1920–1934 was 1,400 kg. As with swedes, the average yield of turnips has varied considerably during the different years. In 1920 it was approximately only 775 kg. per ha., while in 1932 it amounted to about 1,800 kg. per ha. During the 5-year period 1920–1924 the average yield was 1,275 kg., while during the period 1925–1929 it was 1,400 kg. per ha. (According to Professor Witte, the average annual yield during the period 1910–1919 was 1,190 kg. per ha.). Statistics show that in Denmark the average annual yield during the years 1926–1933 was only 800 kg. per ha.

The quality also of Scanian seed of forage roots is very good, and since now Swedish strains of roots are available, as a result of the excellent work carried out by the Swedish plant breeding institutions, and in addition well arranged strain trials with roots are being conducted in which the different strains are tested in a reliable and impartial manner, in future seed production of fodder roots in Scania should not be continued on the same scale as in recent years, but should be increased to the extent which is required.

POLLINATION AND SEED FORMATION OF THE CLOVER SPECIES.

Otto Valle

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[Translated from Swedish by R. Peter Jones.]

Recent investigations conducted by A. Pedersen, Chr. Stapel and H. Wexelsen show that the question of pollination and seed formation of the clover species and particularly of red clover is urgent in the Scandinavian countries at the present time. In Finland also an elucidation of the question is of special importance in connexion with the effort to become as self-supporting as possible in regard to clover seed. Since the spring of 1933 the importation of red clover seed has been prohibited, but especially during poor seed years supplies from abroad are necessary. Alsike clover has only to a limited extent been grown for seed, so that the commercial seed particularly is of foreign—Swedish and Latvian—origin. Seed production of white clover is still in the experimental stage in Finland, for which reason only foreign seed is found on the market.

Investigations into the pollination and seed formation of the clover species have been conducted at the Plant Breeding Station at Tammisto near Helsinki, but only during the two summers 1933 and 1934. The account which follows is based in the main on the results of these investigations.

Observations regarding insects which visited flowers of the different species of clover were conducted during the flowering period, notes being made daily on such insect visits within marked out plots. As in some shifts red-, alsike- and white clover grew near one another it was possible to carry out observations regarding insect pollination of the different clover species under identical conditions. The observations were, as far as possible, conducted twice a day, in the morning and in the afternoon.

Within the same plots where these observations were made, during the flowering period cotton of different colours was used to distinguish the flower-heads so that seed formation could be determined in the heads which flowered at different times. Seed formation per flower-head was subsequently ascertained, taking into consideration in addition to the quality of the seeds which had been developed during the different periods the injuries caused by noxious insects.

Visits of Humble Bees and Honey Bees to Clover Species.

Red Clover. Among the insects which visit red clover flowers, humble bees are most general. Nine species of *Bombus* were noted, some of which were more common than others, namely, *B. terrestris*, *B. lapidarius* and *B. distinguendus*. Other species which occurred, but less generally than those mentioned, were: *B. hortorum*, *B. agrorum*, *B. hypnorum*, *B. equestris*, *B. rudearius* and *B. pratorum*.

In Table 1 some of the results of the observations conducted in 1933 on 4 plots (I–IV) at Tammisto are given. The four plots were situated within an area of about 1 sq. kilometre.

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* Translation of the article: "Undersökningar över klöverarternas pollination och fröbildning." [Investigations on pollination and seed formation of the clover species.] Nord. JordbrForskn. 1935. No. 4-7. Beret. Nord. JordbrForsk. 5. Kongres. København, 1935. pp. 489–497.

Table 1. Observations made during the summer of 1933.

Seed plot	Total number of humble-bees during the observation period	Different humble-bee species per cent				
		B. terrestris	*B. distinguendus*	*B. lapidarius*	*B. hortorum*	Other *Bombus* species
I	688	8	53	17	13	9
II	487	25	36	13	8	18
III	426	54	39	—	1	7
IV	775	74	20	4	1	1
	Average ..	40	37	9	6	8

It is seen from the table that the numbers of the noxious species *B. terrestris* vary considerably for different plots even within the same area ; plot I shows only 8 per cent, while the corresponding figure for plot IV is 74 per cent. The *B. terrestris* workers have, judging from observations at Tammisto, occurred on red clover as robbers only. The more numerous they were, the poorer was seed formation. For the rest the amount of seed formation depends on various other factors, such as *inter alia* the presence of the useful species of humble bees, the time of the occurrence of *B. terrestris*, also on whether the seed destroyers are present in larger or smaller numbers. It is therefore difficult to indicate exactly how much loss *B. terrestris* entails in seed formation in red clover. As an example it may be mentioned that in plot I, where the percentage figure for the occurrence of *B. terrestris* was 8, 66 per cent of the florets examined had developed seed, while in plot II, where the corresponding percentage figure was 25, only 33 per cent had developed seed. Apart from *B. terrestris* no noxious species of humble bees visited red clover, with the exception of *B. lapidarius*, the small workers of which species sometimes also appeared as robbers.

Of the useful species of humble bees *B. distinguendus* was very general, on the average as general as *B. terrestris*. Of *B. distinguendus* there occurred on the average 37 per cent ; of *B. lapidarius* 9 per cent, and of *B. hortorum* 6 per cent.

Observations at Tammisto were continued during the summer of 1934 (see Table 2), plots II, III, and IV being identical with the corresponding plots of the previous summer.

Table 2. Observations made during the summer of 1934.

Seed plot	Total number of humble-bees during the observation period	Different humble-bee species per cent				
		B. terrestris	*B. distinguendus*	*B. lapidarius*	*B. hortorum*	Other *Bombus* species
I	274	41	32	22	2	3
II	717	33	39	16	5	7
III	287	12	56	8	5	19
IV	187	24	32	33	3	8
V	557	26	54	11	6	3
VI	556	27	44	20	5	4
	Average ..	27	43	18	4	8

In the summer of 1934 *B. terrestris* individuals were not so numerous as in the previous summer, the average being 27 per cent. Among the useful species *B. distinguendus* was most general, 43 per cent. For *B. lapidarius* the average figure is 18, and for *B. hortorum* 4. On the whole *B. lapidarius* in the summer of 1934 appeared in considerably larger numbers than in the previous year.

The observations made at Virolahti in South Finland in the summer of 1934 differ greatly from those at Tammisto. Among the useful species of humble bees certainly *B. distinguendus* with an average of 31 per cent was most general, but *B. hortorum* (23 per cent) and *B. agrorum* (16 per cent) were also present in large numbers. The percentage figure for the noxious *B. terrestris* was 17.

To ascertain the importance of honey bees their occurrence at Tammisto in the red clover stands during the summer of 1933 and 1934 was carefully observed. In the summer of 1933 it was possible to determine that honey bees occasionally visited florets of red clover ; in a seed plot during the whole flowering period their number was approximately 5 per cent of that of humble bees. These honey bees were, however, of no use for seed formation, because they appeared as a rule after *B. terrestis* and sought to reach the honey in the florets by way of the holes which *B. terrestis* had made in the corolla tubes. The honey bee, therefore, did not visit red clover as a pollinating insect, while on the other hand it occurred in large numbers on the neighbouring alsike- and white clover florets. Thus it seemed as though the honey bee was of no significance as far as the pollination of red clover was concerned.

After the observations carried out in the summer of 1934, one was forced to change that opinion. In the middle of July that year it was possible to observe clearly at Tammisto how the honey bee appeared on the red clover florets as a pollinating insect in the same way as the useful species of humble bees. As soon as this was observed, the behaviour of the honey bees was noted more carefully. All the honey bees did not pollinate the florets ; some of those which occurred on the red clover florets sought to steal honey through the holes cut by *B. terrestris*. In many seed plots isolated from each other it was possible to establish the occurrence of pollinating honey bees, although in general they were not too numerous in comparison with the humble bees. The main point was, however, that during a certain definite time towards the end of July one could ascertain daily that honey bees occurred as pollinating insects. When one observed the work of some certain individual it was seen that the same individual appeared regularly as a pollinating insect or as a robber. It was possible to observe one individual uninterruptedly during the whole time it visited 284 florets, and it is a fact that it acted without exception as a useful, pollinating insect.

The honey bees occurred in larger numbers the nearer the seed plot was to the hives. The nearest red clover seed plot was about 50 metres away from the hives, and in this plot the honey bees were quite numerous, 41 per cent of the total number of humble bees and honey bees. Of the honey bees that visited this seed plot 45 per cent were useful, pollinating insects. Within seed plots at a distance of 1 kilometre from the hives honey bees constituted only 1·6 per cent of the total number of humble bees and honey bees.

The observations carried out up to the present in Finland indicate, therefore, that honey bees, unless special measures are adopted (feeding of the hive with sugar solution and moving of the hive to a place in the vicinity of the seed plot) do not play nearly so large a part in seed formation of red clover in that country as they do for example in Denmark (Stapel, Pedersen) and in Norway (Wexelsen).

Alsike clover and white clover are as is known valuable honey plants, and therefore large numbers of honey bees visit the florets of these species. As at Tammisto plots of red, alsike and white clover are situated near one another in the same shift, it was possible to observe to what extent under identical conditions the different kinds of insects visit the florets of the various species of clover.

The results of the observations conducted in two different areas are presented in Table 3. The various species of clover were under observation contemporaneously. Plot VI was situated approximately 500 metres and plot V approximately 1000 metres away from the beehives.

Table 3. Visits of bees to different clovers.

Seed plot		Total number of humble-bees and honey bees during the period of observation	Honey-bees per cent	Humble-bees per cent
VI	Alsike clover	858	82·3	17·7
	White clover	685	95·8	4·2
	Red clover	565	1·6	98·4
V	Alsike clover	1306	93·0	7·0
	White clover	660	97·7	2·3
	Red clover	607	8·5	91·5

Table 3 shows that the honey bee is one of the most important of the insects that effect pollination of alsike and white clover. In plot VI humble bees visits to alsike clover constituted 17·7 per cent of the total humble bee and honey bee visits. The florets of white clover were visited almost exclusively by *B. lapidarius*, those of alsike again by *B. lapidarius*, and by *B. terrestris* in large numbers. It is to be noted that *B. distinguendus*, which was the humble bee species which predominated on the adjacent red clover stand, did not visit the florets of alsike and white clover.

As the honey bee plays so outstanding a part in the pollination of alsike and white clover it is of importance that beehives should be placed near alsike and white clover seed plots. Other pollinating insects also visit the florets of the various species of clover, e.g. butterflies. They are, however, of but little significance for seed formation.

Figures 1, 2 and 3 show the extent to which humble bees and honey bees visited the florets of red clover, alsike and white clover during the flowering period in the summer of 1934 (June 26–August 2). The observation results refer to seed plot VI at Tammisto. In Fig. 1 the daily rain records are represented in addition. The dotted line indicates the course of flowering ; in red clover flowering reached its zenith on July 16, in alsike on July 6, and in white clover on July 3. The unbroken line shows the total number of humble bees and honey bees per 100 sq. metres.

Humble bees did not appear in large numbers on the flower heads of red clover (Fig. 1) until after July 10, when flowering was already quite far advanced. At the time of full florification the number of humble bees and honey bees per 100 sq. metres was approximately 70. The largest number was observed on July 16, namely, 100 per 100 sq. metres. As is seen from Table 3, in plot VI honey bees represented only 1·6 per cent of the total number of honey bees and humble bees.

As regards alsike (Fig. 2) considerable daily differences were established for honey bees (82·3 per cent) and humble bees (17·7 per cent), according to weather conditions. As the figure shows, pollinating insects occurred in relatively large numbers as early as the beginning of the flowering period. At the time of full flowering the number of pollinating insects per 100 sq. metres rose to 80 and even more. The maximum was reached on July 12, namely, 164 per 100 sq. metres.

In the white clover plot (Fig. 3) the occurrence of honey bees (95·8 per cent) and humble bees (4·2 per cent) resembled on the whole that in the alsike plot. The number of pollinating insects per 100 sq. metres was however less, below 100.

SEED FORMATION.

For the determination of seed formation during the various times of flowering, cotton differing in colour was tied, usually at weekly intervals, to flowering-heads in the plots, and at the same time observations on insect visits were made. At the time of ripening of the seed the flower-heads were carefully set aside, and seed formation was investigated during the autumn.

Table 4. Investigations on seed formation in the summer of 1934.

	A	B	C	D	E	F
Seed plot VI.			Red clover			
Time of flowering	–	–	7/7	14/7	23/7	30/7
Florets per flower-head ..	–	–	129·4	130·7	99·7	82·1
Seeds ,, ,, ,, ..	–	–	78·5	95·1	70·7	48·9
Seeds per floret	–	–	0·61	0·73	0·71	0·60
			Alsike clover			
Time of flowering	26/6	2/7	9/7	16/7	23/7	–
Florets per flower-head ..	61·5	64·4	60·6	52·8	45·0	–
Seeds ,, ,, ,, ..	135·4	146·4	125·8	63·7	69·2	–
Seeds per floret	2·20	2·27	2·08	1·21	1·54	–
			White clover			
Time of flowering	25/6	2/7	9/7	16/7	23/7	–
Florets per flower-head ..	60·9	54·1	46·4	47·4	38·4	–
Seeds ,, ,, ,, ..	168·9	138·0	98·0	104·4	95·7	–
Seeds per floret	2·77	2·55	2·11	2·20	2·49	–
Seed plot V.			Red clover			
Time of flowering	–	–	7/7	14/7	23/7	30/7
Florets per flower-head ..	–	–	101·2	114·6	111·7	100·2
Seeds ,, ,, ,, ..	–	–	46·7	69·8	85·1	65·8
Seeds per floret	–	–	0·46	0·61	0·76	0·66
			Alsike clover			
Time of flowering	25/6	2/7	9/7	17/7	23/7	–
Florets per flower-head ..	60·9	65·9	48·9	43·1	39·9	–
Seeds ,, ,, ,, ..	131·9	127·6	88·7	59·8	58·8	–
Seeds per floret	2·16	1·94	1·81	1·39	1·47	–
			White clover			
Time of flowering	25/6	2/7	9/7	–	–	–
Florets per flower-head ..	52·6	47·5	43·8	–	–	–
Seeds ,, ,, ,, ..	113·3	95·7	73·8	–	–	–
Seeds per floret	2·15	2·01	1·69	–	–	–

In Table 4 the results of the investigations conducted in the summer of 1934 on two seed plots at Tammisto are presented. The seed plots in question are V and VI, results from which have already been cited in Tables 2 and 3 and also in Figs. 1 to 3. The flower-heads were divided into several classes (A–F) according to the time of

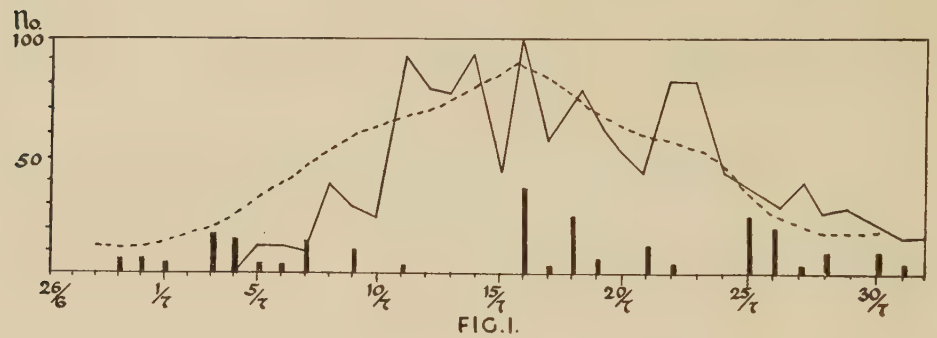

FIG. 1.

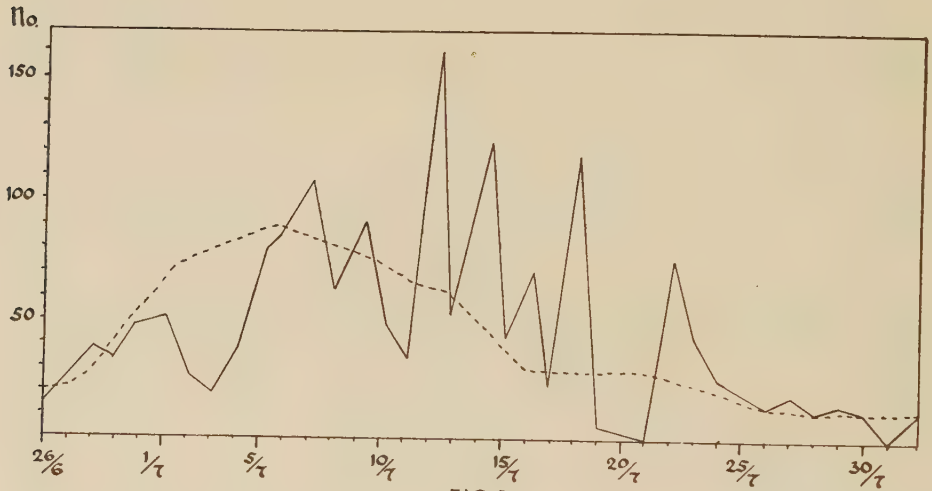

FIG. 2.

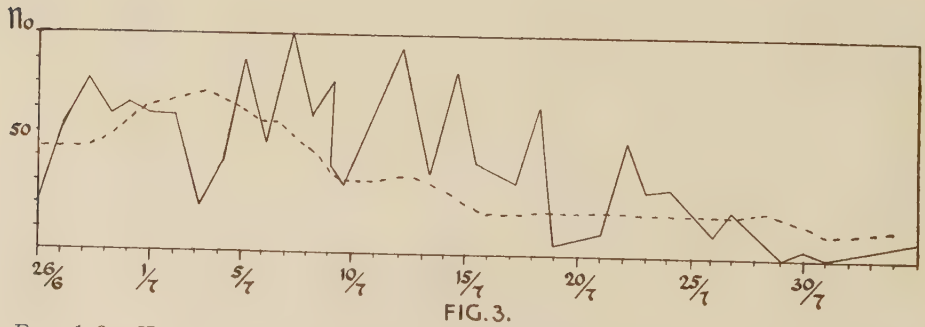

FIG. 3.

FIGS. 1–3.—HUMBLE-BEE AND HONEY-BEE VISITS TO RED CLOVER (FIG. 1), ALSIKE CLOVER (FIG. 2) AND WHITE CLOVER (FIG. 3) DURING THE FLOWERING PERIOD AT TAMMISTO, 1934. HUMBLE-BEES AND HONEY-BEES PER 100 SQ. METRES. THE DOTTED LINE SHOWS THE COURSE OF FLOWERING.

flowering. In each class generally 20–30 flower-heads of the respective species were examined, the number of florets and the amount of seed per flower-head being determined, also the number of seeds developed per floret. As seed plots V and VI were 1-year leys, plant destroyers were not too numerous.

In seed plot VI seed formation was most abundant in classes D and E, 0·71–0·73 seeds per floret. Earlier (before July 14) and later (after July 23) seed formation was not so abundant. This seed plot was 2,900 sq. metres in extent, and the yield of seed amounted in the summer of 1934 to 462 kg. per ha. Thus the result was satisfactory in spite of the fact that 27 per cent of the humble bees that visited the florets during the flowering period consisted of *B. terrestris* (see Table 2). In the same seed plot seed formation in alsike clover varied from 1·21 to 2·27 seeds per floret. Seed formation was abundant in the flower-heads which flowered at the beginning of the flowering period (class A), as pollination did not depend on the occurrence of humble bees. The alsike plot comprised 1,800 sq. metres and the seed yield per hectare was 329 kg. White clover showed an even more abundant seed formation than alsike clover; it varied from 2·11 to 2·77 seeds per floret. The white clover plot was 1,800 sq. metres in extent and the seed yield amounted to 185 kg. per ha.

Seed plot V showed similar results to plot VI. Thus seed formation in the flower-heads of red clover was less at the beginning of the flowering period than later, while alsike and white clover again developed seed abundantly even during the earlier phase of flowering.

The investigations which have been conducted at Tammisto concerning the pollination and seed formation of the clover species show that seed formation is quite abundant even in alsike and white clover. As seed production of these two species in Finland is further developed, attention should be paid to various other matters. Thus it has been established that in alsike and white clover the seed has a tendency to germinate in the flower-head—a circumstance which would appear to render seed production very difficult when the weather is wet at the time of ripening of the seed.

It is intended to continue the researches concerning pollination conditions in red clover, which is the most important grassland legume for ley cultivation in Finland. A more thorough investigation of the part played by the honey bee in connection with the pollination of red clover under the conditions prevailing in Finland should be carried out.*

* Investigations were also conducted during the summers of 1935 and 1936.

REVIEWS

THE FORAGE PROBLEM IN URUGUAY.

[Reviewer : G. M. ROSEVEARE.]

A PLAN of work on this question has been proposed by the Special Commission appointed to study the forage problem in Uruguay, and adopted by the Government in April, 1936. The Report, details of which are made available to readers through the courtesy of our Uruguayan correspondent, was dated Montevideo, March 24, 1936, and signed by the President, Dr. A. Boerger, the Secretary, F. Vidiella, and the other members of the Commission, Daoiz L. Sanz, Socrates Rodriguez, José Elorza, Jacques de l'Harpe, and Cayetano Lemolle y Ottado.

* * * * * *

For the solution of the forage problem it is necessary to classify the environmental circumstances under which it is to be studied. It is, in fact, the economic factor which governs the emphasis to be laid upon this or that aspect of the question, and for this reason it is convenient to divide the farming systems of Uruguay into three large groups : intensive, semi-intensive, and extensive.

As far as the intensive system is concerned, the cut leys which give heavy yields during different months of the year (oats, barley, rye, forage wheats, maize and sorghum according to the different classes of soil) and the silo, as the most economic example of foresight in the provision of forage, constitute the types most generally in evidence at present. These should be supplemented by the search for a legume (if possible an annual, in view of the short terms of the leases) to increase the protein content of the fodder and to correct its calcium deficiency, thus preventing cases of hypocalcemia, a disease produced on dairy farms by a deficiency of calcium and successfully controlled in some parts of the Argentine Republic by substituting crops of oats for those of barley and forage wheat. It would also be interesting to make a trial of legumes which would be suitable for ensilage with oats and maize ; these would include vetch in combination with oats, and soybeans, sweet lupins or possibly cowpeas in combination with maize. In this type of farming it is also necessary to obtain a hardy lucerne, giving a good yield per cut together with appreciable growth in winter and spring, a type such as might be selected from the forms of Peruvian and related lucernes. Conceding the importance attached to the patches of bleached soil* by the literature on the subject (especially that of Dr. Walther), it is necessary to solve this problem in intensive farming. For this purpose it would be necessary to resort to the use of green manure, farmyard manure, or to the cultivation of lucerne, whose persistence under such circumstances in spite of the previous application of organic manures is relatively ephemeral (hardly three years) ; obtaining thereby only modest yields but, as has been proved by experience, the restoration of a relatively satisfactory degree of soil fertility.

In semi-intensive farming the pastures are the fundamental problem ; for winter grazing, oats, barley, and low-growing wheats are used, before the stalks are formed, as these crops offer most resistance to trampling ; Sudan grass is the summer pasture. Other crops which deserve a trial are *Lolium multiflorum* and possibly *Bromus unioloides* as winter crops, and Rhodes grass (*Chloris gayana*) as a summer crop,

* Patches of land several metres in diameter found on slopes, where, generally as a result of long use as arable land, leaching has removed all organic substance, leaving a sandy, greyish, sterile soil.

since the former reseed themselves and give a good yield, while Rhodes grass is very productive and is a perennial. All resist trampling. Here also an important problem is the search for a valuable legume which resists trampling during the winter in clay lands and which is tolerant of drought.

In extensive farming, tillage is generally ruled out for economic reasons. It is necessary here to improve natural grazing lands with special forms of cultivators. It will always be necessary to study the existing vegetation in order to determine the most suitable period for cultivation to encourage the propagation of good species and to prevent the distribution of poor species. Complementary to this would be the dissemination of the seed of good indigenous and exotic grasses, either directly or by means of "dissemination polygons," according to the natural germinability of the grasses and bearing in mind the economic factors, which would allow of germinability being artificially induced by the alternation of low and high temperatures in germinators.

In this type of farming the osteomalacia zones present a special problem which might be solved, according to circumstances, by :

(1) The dressing of a certain area of the affected grazings with calcium-phosphates ;
(2) The distribution of mineral licks (calcium and phosphates) in the grazings ;
(3) The dissemination of legumes adapted to lime-deficient environments, as, for example, *Adesmia bicolor* or *Ornithopus sativus*.

To summarize, the plan of action in accordance with the terms of reference embraces :

INTENSIVE MANAGEMENT.

Trials of forage plants for cutting, in pure sowings and in mixtures with suitable legumes according to the class of soil (predominantly clay or sandy). Ensilage of these plants. Experiments in the use of green manure, farmyard manure, composts, and in the cultivation of lucerne for the restoration of soil fertility in the bleached soil areas.

SEMI-INTENSIVE MANAGEMENT.

Trials of herbage plants for grazing, grown in pure cultures and in mixtures with suitable legumes. Trials of these plants for fattening calves, lambs, capons, and steers, with special reference to the quality of the meat. Experiments concerning the relation of wool and milk yield to the fodder employed. Improvement of reserve grazings, especially for the winter.

Generally speaking, the following are the types of soil on which the various forage crops must be tested : those which are predominantly clay ; predominantly sandy ; rich and poor respectively in humus ; acid, neutral, or slightly alkaline.

EXTENSIVE MANAGEMENT.

The establishment of zones of better pastures in the country. Feeding trials with cattle and sheep with special reference to the quality of the product (meat and wool). Experiments in harrowing or cultivation for the improvement of natural grasslands on different types of soil (classification as in the previous paragraph). The possible ensilage of weeds such as milk thistles and cardoons (*Cynara cardunculus* L.) etc., when cleaning up grassland.

The subject of concentrates has not been included, as they are considered suitable only in the case of high-priced animals such as ewes, when their use is based entirely upon the application of tables for the calculation of rations (Kellner's and others) and requires a knowledge of the market prices of the different feeding stuffs in order to decide the most economical and convenient rationing. The most urgent problems are those whose application is an immediate necessity ; they relate to the very heart of the forage problem, the production of high quality meat and the increased production of wool and milk under economic conditions.

The law of January 29, 1919, having decreed that experimental work should be carried out at the Institute of Applied Botany, La Estanzuela, it is considered that, in order to ensure unity of action, the practical demonstrations to be made on a large scale on private estates and farms should also be conducted in connexion with the above-named Institute.

From what has been said it follows that the principal tasks to be accomplished within the scope of the 15,000 pesos granted for the solution of the national forage problem are as follows :—

(1) Foresight in regard to the supply of fodder.
(2) Experiments in the economic feeding of dairy cows.
(3) Experiments in the fattening of steers and capons.
(4) Grassland improvement.
(5) The distribution of seeds.
(6) The distribution of fertilizers.
(7) Trials of calcium licks in the osteomalacia zones.

Foresight in regard to the supply of fodder.—The last drought, which assumed such proportions as to reduce the volume of water in a river like the Olimar, imperilling the success of important rice crops and discouraging the agricultural producers of the country, constitutes one of the many lessons which once more emphasize the absolute lack of any foresight in Uruguay in the matter of the fodder supply. And this in spite of the recent awakening of intensified interest in the use of silos caused by the economy and efficiency of the ensilage process, an interest which unfortunately could not be put into practice to the extent desirable owing to the lack of personnel capable of taking charge of such work. It has, therefore, been one of the principal aims of the Commission to supply this want by appointing experts to instruct farmers in the advantage of ensilage through practical, large scale demonstrations conducted on farms in different parts of the country.

Generally the period of ensiling oats, barley, rye, grass, and milk thistles and cardoons extends from the beginning of October to the middle of December throughout the Republic. Sweet and bitter maize and sorghums are ensiled from the beginning of February to the beginning of June. The tasks connected with ensilage would represent a total of approximately six months' work.

Experiments in the economic feeding of dairy cows.—As is well known, millions of pesos are spent annually by the dairy industry in the purchase of bran, whereby (owing to the high prices of milling by-products) the development of this important farm industry is greatly hindered. As a consequence the dairyman is deprived of his profits, while at the same time (without benefit to the farmer) an article of such primary importance as milk is made dearer.

Trials of silage and sorghum mixed with soybeans in progress at La Estanzuela will furnish a fodder rich in protein, and feeding trials will show the extent to which it may replace bran in the daily winter ration. Similar trials in the ensilage of milk thistles, cardoons and bitter maize are being initiated by the Commission on private farms this winter. Sunflowers are to be ensiled at La Estanzuela, with a view to ascertaining whether the consumption of this fodder increases the fat percentage in milk, an important factor since the price of the milk to factories is fixed according to its fat content.

Experiments in the fattening of steers and capons.—These experiments will take place in artificial leys (oats, Sudan grass, etc., sown singly or in mixtures with legumes) and on natural grassland, as well as on natural grazings alone (reserve grazings). At least four trials will take place this year, controlled in the same way as those previously described, with a record of the respective costs of production. Each lot will be composed of approximately 30 young steers and 50 to 60 capons.

Grassland improvement.—The Commission will initiate this work by the acquisition during the present year of a tractor, a grassland renovator, and a motor truck

for carting the seeds and fertilizers to be distributed. This equipment will be used normally in the months of September, October, March, and part of April.

If the results of practical tests of this equipment are favourable, the Commission will proceed to acquire further equipment in the following year until three sets are available for working simultaneously in different parts of the country.

The Commission considers that it is absolutely necessary that it should have at its disposal 10,000 pesos for a more complete study of the different soils bearing the country's pastures and above all for the distribution of the seed of good herbage plants to improve the natural grasslands. In view of the high price of grass seed, 6,000 pesos would be required for the improvement of 1,000 hectares, an area equivalent to five demonstration fields. And if in addition the patches of bleached soil are to be eliminated with the aid of vegetable manures, etc., it may easily cost more than the remaining 4,000 pesos to carry out the demonstrations which are to show farmers how the difficulties are to be solved.

Thus, the study of the soil in its relation to the existing pastures, its eventual improvement (distribution of seed), and the grave problem presented by the bleached land may be expected to involve the expenditure of 10,000 pesos on agrostological studies. In this manner it will be possible to carry out experiments which will result in the total improvement of 1,000 hectares annually by fertilization and the dissemination of valuable forage plants, under conditions which will permit reliable conclusions to be drawn in regard to the forage problem.

* * * * * *

While discussing the forage problem in Uruguay reference may be made to a lecture delivered by T. Henry to the Rural Association of Uruguay, in which was presented an outline of the study and improvement of forage and industrial crops already accomplished and in progress at the Institute of La Estanzuela (*Arch. fitotéc. Uruguay*. 1. 243–57. 1935). The subject is considered under four heads.

(1) The protein problem. The protein-deficient nature of the natural grasslands, due to the preponderance of Gramineae, renders the search for legumes which can be adapted to the conditions of Uruguay a matter of primary importance. Lucerne offers the most promising material. Acclimatization trials, selection and reproduction have been in progress since 1914, and more intensively since 1929, while hybridization is to be undertaken shortly. Other legumes which have been the subject of investigation and trial are *Trifolium* (*T. pratense, T. repens, T. hybridum, T. alexandrinum, and T. subterraneum*, results practically negative) ; *Glycine hispida* Maxim., which has been improved by selection and promises very well ; *Lupinus* spp. (still in the experimental stage, *L. albus* and *L. angustifolius* being considered of promise for Uruguayan conditions) ; Vicia spp. (trials and selection in progress since 1931 show that the plant will probably be useful for winter grazing) ; *Lotus corniculatus* (in course of selection) ; and *Lespedeza* and *Lathyrus* species.

(2) Forage supplies for the intensive and semi-intensive forms of farming. In this connexion forage cereals (wheat, oats, barley and rye) are of great importance. Mowing, grazing, and variety trials are described. Rieti wheat, a strain bred at La Estanzuela, has proved of particular value. The breeding of grasses is in progress, notably of Sudan grass (*Andropogon sorghum* var. *Sudanense*, breeding for types free from or low in HCN, *Bromus unioloides* (form resistant to *Ustilago bromivora* desirable), *Lolium multiflorum, Stenotaphrum glabrum* and *Paspalum dilatatum*. The reproduction of Rhodes grass (*Chloris gayana*) and *Pennisetum purpureum* for propagation purposes is in progress.

(3) Research and supervision to be undertaken by the La Estanzuela Institute in connexion with the work of the Government Commission for the study of the national forage resources (see also *Herb. Rev.* 3. 173–4. 1935 and the earlier part of this review) are outlined.

(4) Industrial plants. Work here is concerned principally with the oil-bearing plants *Glycine hispida* Maxim., *Helianthus annuus*, and *Arachis hypogaea*.

HAYMAKING ON FRAMES.

[Reviewer : G. M. Roseveare.]

One of the topics to which considerable attention has been given in European literature during recent years is the drying of grass and forage crops on various types of frames and other structures. This review has been prepared for the benefit of persons who may be concerned with difficulties in the proper and rapid drying of hay or seed crops owing to excessive rainfall or humidity at time of harvest. The information available is so extensive that it has been found necessary to limit the review to German and Swiss publications.

Loss of Nutrients.

A close study of the losses of nutrients in drying hay incurred through respiration, mechanical injury (the breaking off of fine, rich parts of the plant), fermentation or sweating in the stack, leaching, and the extra expenditure of energy by the animal in digesting hay, has been made in Switzerland, notably by Wiegner and Crasemann at Zürich and Landis at Bern. Crasemann and Steiner in 1931 (**9**), reporting on a three years' comparison of drying hay on the ground and on Steinach huts and Allgäu Heinz frames, record that the loss resulting from drying on the ground was, under the best weather conditions, approximately 40 per cent starch equivalent, under bad conditions from 48 to as much as 62 per cent. On frames the loss of starch equivalent was generally from 33 to 38 per cent under favourable conditions, but might be as much as 52 per cent. Loss of digestible protein varied according to harvest conditions from 23 to 62 per cent with ground drying and 21 to 44 per cent with frame drying. Landis, of Liebefeld, Bern, discussing in 1932 (**28**) the results of twelve trial cuts, irrespective of weather conditions, finds the mean yield of starch units per hectare per annum to be as follows : drying on the ground, 37·90 quintals ; on hut frames, 41·65 ; on Swedish fencing, 42·50 ; on Tyrolean posts, 39·97. He considers the main advantage of drying on frames to lie in the reduction of loss resulting from leaching and from the breaking up of the plants by handling. Crasemann in 1934 (**10**) analyses the loss of mineral content as affected by ground-drying and drying on hut frames and posts : loss of crude ash, with drying on the ground, was under favourable circumstances 4·9 to 9·2 per cent ; under unfavourable circumstances, 30 to 41 per cent. On the frames loss of crude ash amounted to 12 to 27 per cent, and was less affected by weather conditions than in the case of hay dried on the ground. Wiegner in 1932 (**43**) discusses experiments conducted by Crasemann from 1921 to 1930, and in 1934, in an address delivered to the Third International Grassland Congress at Zürich (**44**), reviews the whole problem of haymaking as illustrated by the Zürich work from 1917 onwards, wherein the loss of nutrients in the fresh herbage, from the time of cutting to the time when it is fed as hay, is studied. In Switzerland, when the hay is dried on the ground, this loss is found to be two-fifths of the starch equivalent and one-third of the digestible true protein under weather conditions described as "excellent to good," in moderately good weather approximately one-half, and in bad weather two-thirds of starch equivalent and digestible true protein alike. Drying on frames was found in bad weather to reduce loss to two-fifths of the starch equivalent and one-third of the digestible protein, that is to say the loss in bad weather was no greater than in the case of hay dried on the ground in good to very good weather. When, however, the weather is very good, loss resulting from drying on the ground may be less than in the case of frame-drying. Approximately 8 to 12 days are required for drying hay on frames in Switzerland ; the process is most rapid when Swedish fencing is used, the longest time is required when the Tyrolean Heinz type of frame is used, the Allgäu Heinz frames and the Steinach huts occupying an intermediate position in regard to the time required for drying. The above findings are based on a study of 79 harvests.

In all the Swiss work referred to above it is noted that, whilst in very good harvest weather there is not very much difference between the nutritive value of hay

dried on the ground or on frames, in uncertain and wet weather frame-drying offers practically the only guarantee of obtaining good hay.

In Germany, where the use of frames is common, the question has also been widely studied. The following are some of the findings. Kirsch, of the University of Königsberg, in 1933, summarizing determinations made by himself and colleagues (23), gives the following figures for percentage loss in comparison with hay artificially dried without loss :

	Yield	Digestible crude protein	Starch equivalent
Hay dried on the ground	23·6	53·9	54·5
Hay dried on frames ..	11·6	8·6	23·7

He considers that the loss due to drying hay on the ground is generally under-estimated, and that even in good weather this is seldom less than 50 per cent of the digestible nutrients. On the other hand the advantages of drying on frames are possibly over-estimated, since the loss of digestible nutrients is only in good weather less than 30 per cent. The benefits of frame-drying are most evident in rainy weather. Meier, Rostock Agricultural Research Station, records in 1933 (32) the following losses in hay dried on the ground : dry matter, 36·4 per cent ; digestible protein, 48·4 per cent ; starch value, 46·7 per cent. It is considered that by frame-drying these losses could be reduced to 20·8, 25·8 and 32·4 per cent respectively. Rehbock, Univ. Königsberg, finds in 1933 the percentage losses from hay dried on frames to be : dry matter, 22·3 ; crude protein, 32·9 ; starch equivalent, 42·3 ; and the percentage losses in hay dried on the ground : dry matter, 23·6 ; crude protein, 53·9 ; starch equivalent, 54·5.

Geith in 1933 (17) gives the following figures for protein yield :

	Digestible protein, percentage	Protein, kg. per hectare	Hay, dz. per hectare
Clover hay, dried on the ground ; 50 mm. rain ..	4·5	202·5	45
Clover hay, dried on Swedish fencing ; 50 mm. rain	8·0	400·0	50
Meadow hay, dried on the ground ; 65 mm. rain	4·0	152·0	38
Meadow hay, dried on Swedish fencing ; 65 mm. rain	7·2	250·8	39

In 1935 (19) he estimates the percentage of digestible protein harvested from ground-dried and frame-dried grass as follows :

	Ground	Huts or Swedish fencing
Meadow hay ..	5·43	8·25
Clover hay ..	6·02	8·95
Lucerne ..	7·25	12·40
Lucerne ..	10·60	14·40

In Great Britain Watson (41) gives the following calculation of losses determined at the Jealott's Hill Research Station in 1932 and 1933, stated as percentages of the fresh grass :

		Dry matter	Starch equivalent	Protein equivalent	Weather conditions
1932	Early hay	25·5	45·0	44·1	Fine
	Ordinary hay	36·7	48·4	53·7	Showery
1933	Early hay	21·2	38·8	29·4	Showery
	Ordinary hay	17·4	33·1	28·7	Fine

1933 is considered to have been a good hay-making year, and 1932 not a bad one.

TYPES OF DRYING FRAME.

Many illustrated descriptions of the various types of frame used on the Continent have been published recently in the more popular agricultural literature of Germany. A handbook published by Dr. Geith, of the University of Leipzig, contains a concise account of the most important types, with an indication of the purpose and conditions for which each is best adapted (19). The following data are taken from this work. Four types are described, three of which are constructed of wood, the fourth of stakes and wire or rope.

(1) *Tripods.*

These consist of six wooden poles of equal length and 7 to 9 cm. in diameter, three of which form a tripod, the remaining three being placed horizontally around the frame some 50 cm. from the ground. The most practical tripod is that composed of 2·50 metre long poles. Larger sizes, with poles 3 to 3·50 m. long, are in use, but they are difficult to load and transport and do not dry the hay so rapidly as the smaller tripods.

The tripod is principally used for the drying of clover, clover mixtures (with a large proportion of clover), lucerne, peas, vetch, and similar legumes and mixtures. Under certain circumstances meadow hay may be dried upon it, but the risk of failure is comparatively great. It cannot be used for green or wet fodder, nor is it recommended for aftermath or cereals. It fulfils its purpose in good weather, but is apt to fail in wet weather. It cannot be loaded until the crop has begun to wilt and is free of dew and rain. Its use is thus to a very large degree dependent upon weather conditions, and it is recommended principally for regions in which rainfall, especially from May to July, is low. Loss of nutrients through respiration has to be reckoned with, and loss through the breaking of the plants is inevitable on account of the already wilted nature of the material, but the losses incurred through leaching and fermentation are insignificant when conditions are favourable.

From twenty to twenty-five tripods per hectare are necessary. The hay may be raked to the tripods, or the latter conveyed on drags to the required positions. Loading is begun at the angles, whereby care must be taken to leave an adequate space free all around the foot of frame and to keep the interior hollow for the circulation of air. A carefully made dome keeps out rain, and in windy localities the dome should be secured by means of weighted rope or wire. Three or four men are required for the work, two to load, and two to complete the work.

(2) *Huts.*

Huts are comprised of two frames or hurdles made of wooden bars from 7 to 9 cm. in diameter, leaning together and supporting each other in such a way that when

loaded they present the appearance of huts (Fig. 1). A very large number of different types and sizes are in use. A height of approximately 1·80 metres is usual, and a hurdle of this height is composed of two erect side-pieces, upon which at least four cross bars, also 1·80 m. in length, are placed so that the bottom one is 75 cm. above the ground, and the remaining three are at regular intervals of 30 cm. If higher hurdles are used the number of cross bars must be correspondingly increased, but experience shows that it is inadvisable to make hurdles higher than 1·90 to 2 m. because of the difficulty of packing them.

Huts may be used for the drying of practically any kind of crop, and, under certain circumstances, for green or wet material. An outstanding advantage is the readiness with which they can be erected, even in stony hill country. Their use is to a large extent independent of weather conditions, although the construction of the hut and the nature of the crop govern this independence, and liability to losses incurred through respiration, mechanical injury, leaching and fermentation is slight.

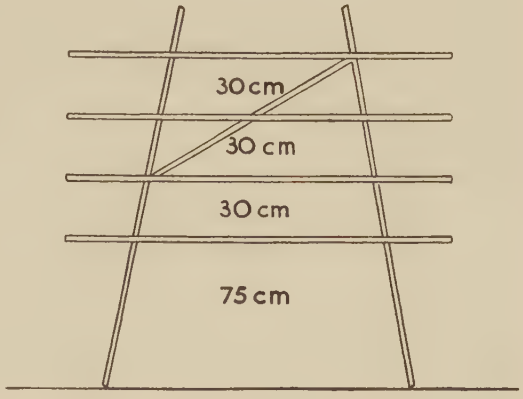

FIG. 1.—DESIGN OF HURDLE, TWO OF WHICH FORM A HUT.

The number of hurdles required per hectare is 160 of the 1·80 m. type or 120 of the 2·20 m. type. Cartage may be facilitated by the use of a specially constructed waggon comprised of very long poles upon which as many as 90 hurdles may be threaded. The process of harvesting green crops by means of huts requires one team to mow, one team to cart and distribute the hurdles, two men to carry hay to the huts, two to load the huts (whereby the hay must be well shaken and loosely hung), and one woman to rake. This allows for the hurdling of approximately three-quarters of a hectare per day. In the case of half-wilted crops the process is as follows: a team mows in the morning, and the crop is turned once. The next day it is turned again, and loaded on to the huts as described above. A distinction to be noted is that in the case of green crops the huts must never have a covering dome, as aeration would be reduced thereby and rotting and mould would result. In the case of partly wilted crops, however, a dome is necessary to prevent the penetration of rain.

An alternative form of hut, which partakes somewhat of the nature of Swedish fencing, has been designed by Inspector Meyer of Chemnitz. Poles or bars 2·40 m. long are erected in pairs along the field at intervals of 2 metres, the two poles of each pair being fastened together at the top by an S-shaped hook. Each pair of poles is connected with the next pair by a 2·8 to 3 mm. zinc-coated iron wire stretching from one S hook to the other, and in each pole notches are cut or nails are driven, the first 75 cm. above the level of the ground, the rest at regular intervals of 30 cm. Through these notches or attached to the nails runs the 1·8 mm. flexible iron wire which forms the hut, and a hut so constructed may be continued to any desired length. It is supported at each end by a stake driven obliquely into the ground. This stake acts as an anchor, and to it are firmly attached the first pair of poles and the ends of the wiring. This type of hut is especially suitable for the drying of green, wet material, which should be loosely packed as in the case of the ordinary huts. It is advisable to have a sweep for the collection of the material.

(3) *The Heinz type.*

This is made of wood, and consists of a single stake, 1·75 to 2 m. long and 4 to 6 cm. in diameter, with three cross pieces in different planes, the first being 60 cm. above the level of the ground, the others at intervals of 35 to 40 cm. above it. The stake is driven into the ground with a mallet (Fig. 2).

This type of frame may be used for green and wet crops, for clover, clover-grass mixtures, lucerne and other legumes, meadow hay and aftermath, but for cereals, potato tops, etc., only under certain conditions. Its use is entirely independent of weather conditions, the loss of nutrients due to respiration, mechanical injury and fermentation is slight and that due to leaching of moderate importance only. It is particularly useful in regions with a high rainfall, for use on steep slopes and for small and medium-sized farms.

From 1,200 to 1,400 such frames are required per hectare. Their cartage, distribution, erection and loading necessitate a considerable amount of experience and skill.

(4) *Swedish fencing.*

This type of frame, as its name indicates, originates in Sweden and is widely used in that country, Norway, Finland and the adjacent parts of Russia. It is now, however, finding its way further south. The fencing is composed of stakes connected either with rope or with wire. (Figs. 3, 4 and 5.)

Rope fencing. The requirements are from 9 to 11 pine stakes, 2·25 to 2·50 m. long and 4 to 6 cm. in diameter, and 50 metres of 4 to 5 mm. thick tarred hempen rope. The stakes are driven in 1 m. apart to a depth of 30–40 cm., the two end stakes in an oblique manner away from the centre. The rope is then attached to the stakes, 60 to 70 cm. above the ground, by being wound once around each stake. The mown crop, well shaken and straightened out, is then forked on to the rope, and when it is loaded to capacity, the same rope is again stretched from stake to stake 25 to 35 cm. above the first layer, packed with hay, and the process is repeated until finally four layers are loaded.

In Central Europe the use of wire is preferred to that of rope, as the rope fencing requires very closely planted stakes to prevent sagging, and expenditure on wood is consequently increased. In addition to this frequent renewal of the rope has been found necessary. The stability of rope fencing in windy localities and soft soil is however, excellent.

Thick wire fencing. Swedish fencing may be constructed with either thick or thin wire. For the former type there are required stakes 2·20 to 2·25 m. long, 5 to 7 cm. in diameter, and wire 2·8 to 3·2 mm. thick. The stakes, which are provided with notches or hooks to support the wire (the use of ordinary nails is inadvisable), are driven in 2·50 to 3 m. apart. A fence should be approximately 50 or 60 m. in length to allow of good anchorage. Pieces of wire, 60 to 70 m. in length, are cut, provided with slots and a hook, and wound four at a time around a roller. Strong anchor stakes are driven in at each end of the frame and the four wires are attached to them. The lowest wire is threaded along the stakes and made taut, the wire above it is threaded loosely in order not to interfere with the loading of the first wire. The lowest wire is first loaded, the second wire is then made taut and packed, and so on until the whole framework with its four supporting wires is loaded. The advantages of thick wire fencing lie in the comparatively small number of stakes required, the tautness of the thick wire and the ease and rapidity with which it can be handled Disadvantages are the need for extraordinarily strong anchorage and the fact that the distance between the four rows of wire is unalterable because of the notches or hooks. If the hay is long results are sufficiently good, but short material is either too tightly packed and becomes mouldy, or is too loosely packed and blows away. The last-named disadvantage is obviated by the use of thin wire fencing.

Thin wire fencing. In this type of fence the stakes must be closer than with thick wire fencing, namely 1·60 to 2·50 m. apart, in accordance with soil conditions

(*Photo : R. Geith*).

Fig. 2.—Hay-Drying on Frames of the Heinz Type.

(*Photo : R. Geith*).

Fig. 3.—Swedish Fences in the Foreground, Hut Frames in the Background, Packed in the Rain.

(*Photo : R. Geith*).

FIG. 4.—MEADOW HAY ON SWEDISH FENCING, SHOWING ANCHOR STAKE.

FIG. 5.—LUCERNE PACKED ON SWEDISH FENCING. (*Photo : R. Geith*).

and the type of crop to be dried, but the wire is merely wound around the posts as in the case of the rope fencing, so that the distance between the rows of wire may be regulated at will. Requirements: stakes 4 to 6 cm. in diameter, 180 to 200 per hectare; and 1800 m. (30 to 32 kg.) 1·8 to 2 mm. soft zinc-coated iron wire per hectare. This wire is sold in rolls or on reels of 1250 m. (25 kg.). Under normal conditions fences 100 to 150 m. in length may be made; in very windy localities and on soft land (moor, transition moor) they should not exceed 30 to 50 m. In such localities greater stability may be attained through increased tension, this being produced by driving the stakes not in the usual straight row, but at obtuse angles to one another, only the two end stakes being in a straight line (see Fig. 6).

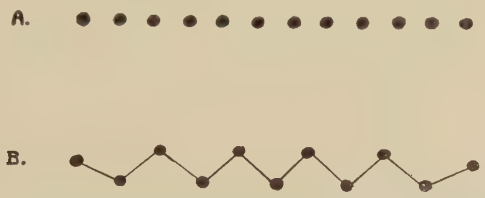

FIG. 6.—SWEDISH FENCE.
A. NORMAL ARRANGEMENT OF STAKES.
B. OBLIQUE ARRANGEMENT.

Swedish fences are constructed as far as possible in the direction of the prevailing wind, generally from south-west to north-east. It is advisable in any case to have lateral supports or anchor stakes every ten to twenty metres. Once the stakes are in position, they may be left standing for several years in meadows, lucerne fields, etc., but the wire should be removed at a convenient time after harvest.

This type of frame may be used for drying clover, clover-grass, clover mixtures, lucerne, pulse of all kinds, especially for seed production, and potato tops. Cereals and beet leaves are better dried on huts. Swedish fencing may be employed under any weather conditions, and liability to loss resulting from respiration, mechanical injury, leaching and fermentation is slight.

Average requirements per hectare are four hundred metres of fencing, comprised of 360 m. wood and 25 to 30 kg. wire. An essential of drying on Swedish fencing is that the crop must be hung or forked on to the fence immediately it is cut. No more is mown, therefore, than can be hung during the course of the day. The crop is most conveniently conveyed to the fences by means of a sweep, and two or three workers pack the fence by hand or with a fork.

* * * * * *

Of the four types of drying frame described it is considered that three, namely, huts, frames of the Heinz type, and Swedish fences, are eminently capable of reducing the loss of nutrients incurred in haymaking.

The above information given by Geith refers to the types of frame most commonly used in Germany. Mattheus (31) summarizes advantages and disadvantages of the different types thus:

Tripods.	Material: little required. Construction: simple. Storage, cartage and erection: convenient. Value for the drying of meadow hay: none. May be used for clover hay in good weather, but even here the preliminary turning which is necessary results in loss of leaf.
Huts.	Material: somewhat heavier requirements. Construction: more difficult, but capable of simplification. Storage and cartage: awkward, much space required. Erection: easy.

Huts.—*con.*	Value for the drying of meadow hay : a considerable improvement on the tripod. No previous turning necessary in good weather, but drying on one side is required, which results in a certain loss of leaf when the grass is handled.
Heinz frames.	Material : a very large amount is required. Construction, storage, cartage, erection : difficult. Value for the drying of meadow hay : only of use in the case of very long grass, i.e. where quality has already deteriorated somewhat. Hay should be loaded on to the frame as soon as cut.
Swedish fence.	Material : approximately the same as in the case of the huts [no mention of wire]. Construction : of the simplest kind. Storage and cartage : very convenient. Erection : not easy. Once erected, however, the stakes may in many cases be left standing. Value for the drying of meadow hay : the best type of frame known to the author. Hay can be packed on to the frame immediately after mowing, even in the rain.

Many modifications of these types of frame are in existence. Berkner and Meyer (**3**) describe frames used in Finland, where a slightly different form of the Heinz frame, huts, and a frame known as the " Swedish harp " are commonly used. The last-named frame consists of a single hurdle or fence made of wood and varying from 2 metres to a very considerable height. A similar harp frame is used in Switzerland, together with a modification of it known as the " Turks' house " (Dinkhauser, **14**). The Heinz frame, as is natural from its special suitability for use on steep slopes, is particularly wide-spread in Switzerland. In Germany a modification of the Swedish frame is described by Brunnemann in the *Mitt. dtsch. LandwGes.* (**6** and **7**), and its merits and demerits are widely discussed in subsequent numbers of the same journal (**1, 4, 24, 25, 29, 36, 45**) ; Derlitzki, of the Pommritz Experiment Station, Saxony describes a further improved form (**12**). Zachmann (**46**) has evolved a collapsible type of hut, claimed to be easy to transport and store. Reese (**34**) notes a method of wiring down the tops of loaded frames to prevent the blowing away of hay. Koch (**26**) and Kunzweiler (**27**) describe the principal types of frame, with special reference to construction; Frintrop (**15**) discusses technique and labour, and Derlitzki (**13**) describes the various types of frame and their uses, including a modification of the Finnish and Swiss harp frame. This frame is a single hurdle constructed of poles with crosspieces of wire, and propped by poles. It is somewhat awkward in use, transport and storage, and is recommended mainly for small areas. In discussing the various frames, Derlitzki notes that the tripod is inexpensive because comparatively few are required per hectare, but stresses their dependence upon weather conditions, since loading cannot be begun until the crop is already fairly well dried. Agena (**2**), Osiander (**33**), Greve (**21**), Gran (**20**), Strecker (**38**), and Weber (**42**) describe modified forms of the hut type of frame. The form evolved by Weber at the Pommritz Experiment Station appears to be a type which might be useful under other conditions, since it differs from the ordinary kinds of hut in being constructed largely of wire. The hurdles forming the hut are composed of 3 vertical poles 6 to 8 cm. in diameter and 2·05 m. in height, and of two horizontal 6 to 8 cm. poles, 4 m. in length. The horizontal poles form the top and bottom of the hurdles, and 5 rows of 2·5 mm. zinc-coated iron wire are arranged horizontally between them, the lowest wire 60 cm. above the ground, the remainder at regular intervals of 27 cm. In economy of wood, and lightness of handling, this type would appear to have definite advantages over the usual hut.

None of the tripods described or illustrated contain air-vent constructions of the type tried in Great Britain. Efficient aeration is effected by leaving the foot of the tripod free all round and the interior hollow (Geith **19**). Everywhere the hut, the Heinz type of frame (particularly on steep land, small areas, or soft soil), and the Swedish fence are considered most suitable for hay.

COSTS.

A study of costs based on experience in Germany and Switzerland, where wood is cheap and readily available, is of value only in so far as it affords a comparison of the expenditure incurred through frame-drying and drying on the ground respectively, and of that attached to the employment of the different types of frame. Herein labour is a factor of importance, but of equal importance is the increased quantity of nutrients obtained, and the financial aspects of both have to be taken into consideration. Bünger, Germany, (**8**), studying cost of material and labour (men and horses), considers the Swedish fence unsurpassed for cheapness. Sommerkamp (**37**) in studying labour costs, gives some figures for the hours of labour required on seven farms, on four of which the hay was dried on frames, while on the remaining three it was dried on the ground. In drying clover on frames on Farm No. 1, there were required per hectare 4·25 hours (horses) and 20·3 (men), in drying meadow hay 7·2 hours (horses) and 30·2 hours (men). When no frames were used the figures on Farm No. 4 for the drying of clover hay were 3·2 hours (horses) and 16·2 (men) per hectare, and on Farm No. 6 for meadow hay 4·75 hours (horses) and 13·0 hours (men). The variation in these figures is attributed mainly to variation in the yield per hectare. Calculating the labour (men) required for producing 1 dz. hay on frames, an average figure of 2·8 hours per dz. is obtained for the four farms employing frames, while the figure for the three farms without drying frames is 2·91 hours per dz. It is noted that the curing of meadow hay requires considerably more labour than the curing of clover or lucerne hay.

Mattheus (**31**) finds the cost of labour less when frames are used. He enumerates the eleven haymaking processes requisite in good weather when hay is dried on the ground ; in bad weather this number is considerably increased. For haymaking on frames, on the other hand, only eight processes, including the cartage, erection, and clearing away of the frames, are required, of which six may be carried out in any weather, even when it is raining. The following figures are given for the cost of labour (men and horses, from mowing to carrying) on four farms :—

Farm	Cost of labour per centner hay	RM.	Quality of the hay	Milk in litres
A	Without frames	0·65		3·51
B	,, ,, ...	0·70	15 kg. suffice to maintain one cow and to produce in addition approximately	6·0
C	Different kinds of frame ..	0·39		7·0
D	Swedish fences	0·48		11·0

The improved quality in the case of C and D is attributed to the higher protein content. On the farm D the grass was mown at a very early, juicy stage, a procedure which is a source of much difficulty under the ordinary method of haymaking.

In connection with the question of labour, Geith (**17** and **19**) points out that statistics are incomplete in that they have no bearing upon the general work of the farm. One of the advantages of haymaking with the aid of frames is that a better distribution of work is ensured ; fine weather may be utilized for work on root crops, while haymaking can be safely relegated to the wet days. He notes further the saving of time : in frame-drying two processes only are involved, (*a*) mowing and loading, (*b*) carrying, so that only two journeys to the field have to be made ; whereas when hay is dried on the ground, a large number of journeys to and from the hayfield must be made in accordance with the number of times the hay has to be turned, and the worse the weather, the greater the number of journeys. This last consideration has particular weight in Germany, where the farm buildings are often widely separated from their fields.

Geith (19) estimates the cost of the frames alone as follows :—

Type of frame	Number required per hectare	Requirements per hectare in		Cost in RM.
		wood	wire	
Tripods	20–25	375 m. 7–9 cm. diam.	–	35–45
Huts 1·80 m. high ..	160	1600 m. 7–9 cm. diam.	–	140–160
Huts 2·20 m. high ..	120	1800 m. 7–9 cm. diam.	–	120–140
Heinz type frames ..	1200–1400	2000 m. 4–6 cm. diam.	–	250–300
Swedish fences ..	400 m. fencing	360 m. 4–6 cm. diam.	25–30 kg.	35–45

The above figures support Bünger's claim concerning the cheapness of the Swedish fence (8). Its cost is the same as that of the tripod, but its efficiency in preventing loss of nutrients is very much greater.

Landis, of Liebefeld, Bern (28), gives the following information on the cost of the frames themselves :—

Type required	Number required per hectare	Cost per frame. Swiss francs.	Potential duration of use. Years.	Interest and amortization per hectare and one cut. Swiss francs.
Huts	150	1·90	10	10·15
Swedish fence	24 × 50 m.	23·60	3–30	14·70
Tyrolean Heinz type, large	160	1·80	12	8·90
do. small	420	1·30	12	16·85
Allgäu Heinz type ..	1200	0·50	10	21·–

The same writer's estimates for labour per hectare, one cut, are :—

Type of frame	Hours (men)	Hours (horses)	Cost of labour. Swiss francs.
Huts	57·1	7·9	55·15
Swedish fence	88·3	2·50	73·65
Tyrolean Heinz type	67·1	3·7	58·15
Allgäu Heinz type	101·25	–	81·–

The corresponding figures for labour when hay is dried on the ground vary greatly in accordance with the weather and the necessity for shocking once, twice, three times,

or (under excellent conditions) not at all, as follows: hours (men), from 30·0 to 87·5 ; hours (horses), from 5·0 to 8·3 ; cost (Swiss fr.), from 30·– to 80·–, per hectare, one cut. From a financial study of the yield of starch equivalent obtained in 12 different harvests, irrespective of weather conditions, Landis found the net average excess profit resulting from frame-drying to be per hectare, per annum : huts, Swiss fr. 92·35 ; Swedish fences, Swiss fr. 77·35 ; Tyrolean Heinz frames, Swiss fr. 39·10. The increase in the yield of starch equivalents was greatest in the case of the Swedish fencing, but costs were slightly higher. The net excess profits from frame-drying in the case of seven cuts harvested under very wet conditions (average rainfall 40 to 50 mm.) were, in Swiss fr. : huts, 44·80 ; Swedish fencing, 49·05 ; Tyrolean Heinz frames, 39·20, the Swedish fencing here taking the first place.

In Great Britain the costs of hand and horse labour in the ordinary ground-drying methods of haymaking were studied by Bond in 1918 (**5**). The cost of the metal tripods with which experiments have been made is noted in the *Trans. Highl. agric. Soc. Scot.*, 1935 (**40**), as 6s. per tripod, and Templeton (**39**) estimates the outlay on tripods and rings as approximately £2 per acre, and their duration 20 or more years. Statistics on the labour involved are not available.

* * * * * *

In summarizing, it may be observed that Continental experience appears to indicate the value of three types of drying frame for eliminating haymaking losses, namely, the hut, the Swedish fence, and frames of the Heinz type. The choice of frame would be largely governed by considerations of economy and locality. While the Swedish fence appears to be the cheapest, the most efficient, and the least dependent upon weather conditions, its place might be more suitably taken on uneven or hilly land by the hut, and here possibly a hut of the type evolved by Weber (**42**), in which wood is largely replaced by wire, would be more suitable for certain conditions. Probably frames of the Heinz type, while producing highly satisfactory results, would be suitable only under special circumstances, e.g. (*a*) on a small scale in seed production, etc., (*b*) on land which is too steep for the use even of huts, or (*c*) in well-wooded districts where the cost of material might not be prohibitive. The heavy initial cost conditioned by the large number required and the high degree of skill necessary for their construction, erection and loading must be borne in mind.

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THE SCANIAN SEED PRODUCTION ASSOCIATION.

[Reviewer: R. Peter Jones.]

A retrospective survey on the occasion of the 25th Anniversary of the foundation of this Association has been published by Dr. H. Witte in "Skånes Fröodlingsförening, 1911–36." Malmö, Sweden, 1936.

On the initiative of Professor Hjalmar Nilsson, then Director of the Swedish Seed Association, the Scanian Agricultural Association organised the first Scanian seed show, which was opened in Malmö on February 9, 1911. On that occasion Dr. H. Witte delivered an address on rational seed production of meadow plants. The address culminated in a proposal that the seed growers in the province should unite to form an association to look after their joint interests. The proposal met with the approval of those present and a committee was appointed to deal with the matter.

On April 12, 1911, the committee invited seed growers and other people interested in seed production in Scania to attend a meeting of the Agricultural Association in Malmö to form a seed growers' association comprising the whole province. The Scanian Seed Production Association was formed and a set of rules was drawn up for its governance. The aim of the work of the Association was to promote rational production of different kinds of seed by means of lectures, distribution of pamphlets on seed production, institution of seed production trials, awarding of prizes for the best seed plots, etc. In addition the Association was to endeavour to set up a seed-cleaning depôt and to arrange for the hiring out of clover hullers, and also to assist members with the sale of the seed which they had produced.

The experimental work of the Association has been of the greatest importance. Trials with late red clover have been conducted since 1912 in which broadcasting and drill sowing, different distances between the drills, and varying rates of seeding have been tested. Seed production trials with lucerne were also set up. Drill sowing and broadcasting were compared in seed production trials with *Phleum pratense*, *Lolium perenne*, *Lotus corniculatus*, *Festuca rubra*, and *Poa pratensis*. Time of cutting trials with Silesian red clover and Italian ryegrass, strain trials with red clover, and seeds mixture trials have been carried out.

From 1912–18 the Association supplied some growers with small quantities of stock seed free of cost, chiefly seed of late red clover, alsike, timothy and cocksfoot, but in a few cases also of meadow fescue, *Bromus arvensis* and *B. inermis*.

During the 25-year period the two hullers owned by the Association have been hired out annually for a great part of the six winter months to members of the Association and other growers.

In the summer of 1932 the board of management of the Association, after conferring with representatives of the Scanian seed firms, prepared a *standard contract* to apply in the contracting of seed plots. At the same time a scheme was worked out for quality-payment for the seed supplied, and this is based on the minimum price of the delivered lot, which corresponds to certain requirements regarding purity, germination and weed content, and also partly on addition or deduction in case the quality of the delivered lot surpasses or falls below the established norms for paying out of the minimum prices.

Data showing the area of seed plots of the more important species of seed in Scania during the period 1925–35 are presented in tabular form.

Although the question of pasture strictly speaking lies outside the sphere of activity of the Seed Production Association, the board of management decided in 1914 to award prizes for well-managed pasture leys in order to stimulate interest in this important matter.

A branch of the Association was established at Alnarp in 1928.

The board of management has on several occasions made representations to the Government regarding protection for indigenous seed production.

CONFERENCES

MELBOURNE, AUSTRALIA, 1935.

The Twenty-second Meeting of the Australian and New Zealand Association for the Advancement of Science was held at Melbourne in January, 1935, and the Report was published by the Association at its Principal Office, Science House, 157–161 Gloucester Street, Sydney, New South Wales, in 1935.

Section K was devoted to Agriculture and Forestry under the Presidency of Professor J. R. Murray, Professor of Agriculture in the University of Queensland and Principal of the State Agricultural College.

Section M was devoted to Botany under the Presidency of Dr. D. A. Herbert, University of Queensland.

The following papers, of herbage interest, were read at this Meeting :

Allan, H. H. The Australian element in the New Zealand flora. A plea for more exact taxonomic studies.
Bartels, L. C. Intensive grazing on irrigated pastures.
Davies, J. G. Seed rates and interspecific competition in seed mixtures.
Edwards, E. T. The witches' broom disease of lucerne.
Finnemore, H., and Jaffray, A. B. The amount of hydrocyanic acid in a blue couch grass, *Cynodon incompletus* Nees.
Hopkirk, C. S. M. Live stock of New Zealand, with special reference to diseases past and present.
Marriott, S., and Winders, C. W. Some problems of Queensland pastures.
Murname, D., and Marston, H. R. Coast disease in South Australia.
Trumble. H. C. The relation of pasture development to environmental factors in South Australia.
Twentyman, R. L. The seasonal production of Victorian pastures and the influence of the application of artificial fertilizers.

STOCKHOLM, 1935.

The meeting of the Swedish Grassland Society, in combination with the meeting of the Central Institute's conductors of experiments, was held at Stockholm on February 6, 1935 (*Svenska Betes- o. Vallfören. Arsskr.* 17. 105. 1935.)

Mr. B. Wallin, a member of the staff of the Swedish Grassland Society, delivered an address on " The laying down of pasture on uncultivated land," in the course of which he dealt with the following points : cultivated or non-cultivated ground for pastures ; pastures put down on uncultivated land frequently prove unsuccessful ; soil types which require thorough cultivation ; results of experiments and other experiences ; soils which are less dependent on surface cultivation ; the degree of thoroughness of soil cultivation necessary and the methods employed ; cost of soil cultivation. An animated discussion followed. R.P.J.

COPENHAGEN, 1935.

As noted in *Herb. Rev.* 3. 98. 1935, the Fifth Congress of the " Nordiske Jordbrugsforskeres Forening " was held in Copenhagen on July 3–6, 1935. The Report is now available and a list of the papers of herbage interest together with the names of the chairmen of relevant sections are given below :

A translation of the paper on " Pollination and seed formation in the clover species," by Dr. O. Valle is printed in this issue of *Herb. Rev.* as a representative paper on current research in Finland. The other papers on pollination in red clover will be the subject of a joint review in the December number of *Herb. Rev.*

Abstracts of all papers will appear in *Herbage Abstracts.*

Section for Seed Production and Seed Control.

Chairman : Professor Dr. H. Witte, Stockholm, Sweden.

Sylvén, N. Seed setting of red clover.
Wexelsen, H. Investigations on pollination of red clover.
Valle, Otto. Investigations on pollination and seed formation of the clover species.
Pedersen, A. Pollination of red clover and attack of red clover by *Apion* sp.
Stapel, C. The pollination of red clover, with special reference to the importance of honey bees.

Section for Biology of Breeding.

Chairman : H. N. Frandsen, Taastrup, Denmark.

Frandsen, H. N. Trade in and multiplication of recognized varieties and strains.
Turesson, G. Ecological differentiation of the plant species with particular reference to cultivated plants.

Section for Animal Husbandry.

Chairman : Professor H. Isaachsen, Ås, Norway.

Steensberg, V. Common norms for the calculation of grass food units for cattle in the Scandinavian countries.

Section for Grassland Cultivation.

Chairman : Dr. A. Elofson, Uppsala, Sweden.

Eskedal, H. W. Danish trials in the conservation of grassland- and green fodder crops.
Poijarvi, I. Results from experiments with A.I.V. fodder.
Isaachsen, H. Conservation of fresh fodder.
Spildo, L. S. Results of conservation of fodder according to the A.I.V. method in Norway.
Edholm, H. Artificial drying of grass at the individual farms.
Gaardmand, P. N. Some facts regarding the curing and preservation of hay.
Giöbel, G. The manurial problem of the leys. Nitrogenous manuring of the pasture leys.
Foss, H. Results of the manuring of meadows with special reference to nitrogen in the inland climate (of Norway).
Giöbel, G. Methods for estimating in experiments the yield of grass fields. Some experiences of experimental methods employed hitherto.

OXFORD, 1936.

A Conference on mechanization in mixed farming was held at Rhodes House, Oxford, on January 7 to 10, 1936, under the joint auspices of the School of Rural Economy, the Institute for Research in Agricultural Engineering, and the Agricultural Economics Research Institute of the University of Oxford. (See below, under Oxford 1937.)

The Conference dealt with three main topics :

The mechanization of rotational farming.
Problems of livestock and grassland.
Harvesting on medium-sized farms.

The following papers were read at the session on January 9 on problems of livestock and grassland :

Hollis, W. D. Stock in relation to mechanized farming.
Abbott, W. S. Folding systems.
Bates, G. H. Mechanization and grassland improvement.
Stapledon, R. G. Long leys and mechanized farming.
Page, H. J. Grass conservation.
Higgs, Clyde. Grass drying on my farm.

The texts of all the papers and also the discussions are printed in *Farm and Machine*, Vol. 3, 1936, published by and obtainable from the Institute for Research in Agricultural Engineering, University of Oxford, price four shillings, post paid. Abstracts of the relevant papers will appear in *Herb. Abstr.*, Vol. 6, No. 4, 1936, but some brief notes on the scope of the various papers in Session 2 will be given here.

W. D. Hollis asked and answered the following two questions :

(1) Can mechanized farming (i.e. almost continuous cereal cultivation) be carried on successfully and for any length of time without stock ?
(2) Can stock be profitably incorporated in a policy of mechanized farming ?

The answer to the first is in the negative and to the second in the affirmative.

W. S. Abbott discussed folding of sheep, poultry and pigs, and gave some details of profits to be gained.

G. H. Bates stated that the improvement of grassland by mechanical means resolves itself into three major processes :

(1) The eradication of matted growth in pastures.
(2) The transformation of the flora of a pasture from an undesirable type to one dominated by *Lolium perenne*, *Poa pratensis* and *Trifolium repens*, or the maintenance of this latter association as the dominant one, a process termed " rejuvenation."
(3) Routine operations for the spreading of dung and molehills and the removal of long coarse grass.

R. G. Stapledon stated that for years he has been " proclaiming the virtues of the four- to six-year ley. All this permanent pasture is anathema to me." By far the larger proportion of permanent pasture in England and Wales is bad—unproductive, not nutritious, full of weeds, seldom yields what is wanted and only when it is not wanted. Of the 2,130,000 acres of permanent pasture in Wales, not 50,000 acres are in something approaching to tolerably good ryegrass pastures.

Mechanization is going to make it easier to break up old grassland and the use of grass for artificial drying will cause farmers to favour the short-term ley, to obtain maximum bulk, maximum nutritive value and maximum seasonal spread-over.

The one-year ley, using red clover and Italian ryegrass, should be considered ; a sequence of such leys taken continuously for three to five years is an admirable method of preparing a poor weedy field for a good four- to six-year ley. Large yields of herbage may also be obtained from certain grasses cultivated in rows, with cleaning between the rows.

There are four distinct advantages of the four- to six-year ley :

(1) A system of ley farming enhances the fertility of the whole farm.
(2) Except on the very best land, leys are more productive than permanent grass on the same land.
(3) A ley is excellent for cleaning fields contaminated by weeds.
(4) A ley gives the scope for producing just the grass required, when it is most necessary, a prime function of the ley in connexion with drying grass.

A ley will have entirely missed its mark unless it contains what it is intended to contain, and the amount desired, for as long as it occupies the ground. Whenever its special grass is lost, it will be useless and should be ploughed. One-year leys with Italian ryegrass and late-flowering red clover ; two-year leys with commercial *Lolium perenne*, commercial *Dactylis glomerata* and Montgomery red clover ; three-year leys and longer with persistent and leafy strains of grasses and, where suitable, lucerne.

H. J. Page dealt with the subject of grass conservation primarily from the point of view of the underlying principles and facts, with incidental mention of methods. All persons interested in the conservation of grass should refer to the report of the Committee of the Agricultural Research Council on " The preservation of grass and other fodder crops." The present paper covers similar ground, but with amplification of certain aspects of the subject by facts and data not available for the Report.

Certain modifications in methods of haymaking, designed to minimize the mechanical and other losses in the field, are commonly used in Europe. These consist in the use of racks, hurdles, stakes and similar devices, on which hay is piled while in a partly dried condition (see the review "Haymaking on Frames" on p. 82 of this issue). By this means the harmful effects of bad weather are lessened, but in good weather the effect is small. Material with the relatively low cash value of hay will not stand the costs involved in generating heat for artificial drying, but the artificial drying of young grass of high quality is quite a different proposition.

After dealing at length with the merits of young grass and presenting many tabulated data, the reader compared wet conservation (ensilage, etc.) with dry conservation (artificial drying of grass). The economic solution of the problem of grass drying depended on the production of a drier which would enable dried grass to be made at a cost sufficiently below the cost of £7 10s. 0d. per ton. This has now been achieved with a comfortable margin (see below) and the widespread adoption of grass drying in Great Britain may be expected.

The question is often asked : " Which is the better method of grass conservation, ensilage or drying ? " There can be no two opinions that drying is intrinsically the better method, for it conserves grass without loss, in a form in which it will keep indefinitely, and in which it is easily handled. Moreover, although dried grass can be fed in amounts to satisfy the whole production requirements of even high-yielding cows, it has not been found that silage can be eaten by cows, in Great Britain, in amounts of more than 70–80 lb. per day, and many cows will not take so much. In spite of this, however, modern improved methods of ensilage are so good that they certainly have their part, not only for the farmer who is unable or unwilling to undertake grass drying, but also for special purposes where a high analysis succulent food—a " watered concentrate "—is useful. Although dried grass must be given pride of place, it and grass silage must be regarded not as mutually exclusive but as complementary methods of conservation.

C. Higgs described the institution of grass drying on his farm and its incorporation in his farming system. Dried grass is produced at a cost of £3 10s. 0d. per ton, a figure which should be reduced later. " Commercial grass drying for the farmer has arrived and represents one of the greatest advances in agriculture for centuries. . . . It is something to live in days when we are not only being shown how to make two blades of grass grow where only one grew before, but in addition, we are now told what to do with it when it is grown."

PULLMAN, WASHINGTON, U.S.A., 1936.

The twentieth annual meeting of the Western Branch of the American Society of Agronomy was held at Pullman, Washington, and Moscow, Idaho, on June 22, 23 and 24, 1936. Weeds and forage crops were the main topics discussed, but papers were also given on cereals and general agronomic topics. Titles for 22 papers were submitted in advance and 4 additional papers were given. The 70 persons registered were mainly agronomists from 8 of the 11 western states and from the U.S. Department of Agriculture.

Mornings were filled with a programme of papers and discussions, while afternoons were devoted to observation trips. On the trips the visitors were taken over the soil conservation nurseries and soil conservation experiment station fields, the Washington and Idaho Experiment Station farms, and the Washburn-Wilson pea-breeding grounds. The banquet on the second evening was attended by a number of guests as well as agronomists.

B. B. Bayles of the U.S. Department of Agriculture Cereal Office was elected President, succeeding R. S. Hawkins ; and Clyde McKee of the Montana State College Agronomy Department was elected Secretary, succeeding E. G. Schaffer. The 1937 meetings are to be held at Bozeman, Montana.—From *J. Amer. Soc. Agron.* 28. 684. 1936.

SWIFT CURRENT, SASK., CANADA, 1936.

The Fifteenth Annual Meeting of the Western Canadian Society of Agronomy was held at Swift Current, Saskatchewan, on June 22 and 23. Following the Presidential Address given by Professor J. H. Ellis, University of Manitoba, the reports of the Variety Zone Co-ordination Committee and of the Farm Machinery

Committee were presented to the meeting by Dr. J. B. Harrington, University of Saskatchewan, and H. J. Kemp, Dominion Experimental Station, Swift Current respectively.

The papers read to the Meeting were grouped into a forage crop symposium, the details of which are given below.

J. Mitchell, University of Saskatchewan, Saskatoon. The soil belts of Western Canada in relation to forage crop problems.
L. E. Kirk, Central Experimental Farm, Ottawa. The suitability of the various forage crops in different soil belts of Western Canada.
T. K. Pavlychenko, University of Saskatchewan, Saskatoon. Root systems of forage crops.
H. J. Kemp, Dominion Experimental Station, Swift Current. Water requirements of forage plants.
L. B. Thomson, Dominion Experimental Station, Swift Current. Relation of carrying capacity of pastures to beef production.
S. E. Clarke, Dominion Experimental Station, Swift Current. Management of forage crops on dry land farms and range lands.
G. F. H. Buckley, Dominion Experimental Station, Brandon. Forage crop management on the black soils and in the aspen grove belt.
F. A. Wyatt, K. W. Neatby, J. R. Fryer, and A. G. McCalla, University of Alberta, Edmonton. Field crop problems on grey wooded soils.
J. H. Ellis, University of Manitoba, Winnipeg. Production of grasses and clovers on peat lands.
J. E. Blakeman, Dominion Seed Branch, Winnipeg. Production of forage crop seed.
G. B. Sandford, Dominion Plant Pathology Laboratory, Edmonton. Forage crop diseases.
Wm. J. White, Dominion Forage Crops Laboratory, Saskatoon. Preliminary results in the crossing of cereals and grasses.
E. A. Hardy, University of Saskatchewan, Saskatoon. Agricultural machinery in the production of forage crops.

FREDERICTON, N.B., CANADA, 1936.

The Annual Meeting of the Canadian Seed Growers' Association was held at Fredericton, N.B., and Deep Brook, Nova Scotia, from July 9th–11th, 1936. The following papers were read at the sessions held at Fredericton on July 10th and at Deep Brook on July 11th.

L. H. Newman, Central Experimental Farm, Ottawa. History and development of the C.S.G.A.
R. Summerby, Macdonald College. P.Q. The work of the C.S.G.A., its object and plan of operation.
H. G. L. Strange, Searle Grain Co., Ltd., Winnipeg, Manitoba. The use of registered seed in the scheme of Canadian agriculture.
W. H. Wright, Dominion Seed Branch, Ottawa. The rudiments of pollination and fertilization of farm crops.
W. J. W. Lennox, Dominion Seed Branch, Toronto. The use of registered seed.
Kenneth Cox, Dominion Experimental Farm, Nappan, Nova Scotia. An analysis of some varieties of oats grown in Nova Scotia.
W. T. G. Wiener, Canadian Seed Growers' Association. The present policy of registration of the several groups of crops.
L. C. Raymond, Macdonald College, P.Q. Root seed production.
W. T. G. Wiener, Canadian Seed Growers' Association, Ottawa. The value of standard seed stocks in root seed production.

Preceding the Conference the three sections of the Plant Breeders' Committee met at the Dominion Experimental Station, Fredericton, on July 7th and 8th to prepare their reports and recommendations for presentation of the full meeting of the Association. The chairmen of these three sections were as follows :

Cereal Crops .. .. L. H. Newman.
Forage Crops .. .. .. L. E. Kirk.
Horticultural Crops .. .. .. M. B. Davis.

The Meeting concluded with trips which had been arranged by the Nova Scotia Department of Agriculture on July 12th.

OXFORD, 1937.

A second Conference on Mechanization is to be held at Rhodes House, Oxford, on January 5–8, 1937. A detailed programme will be available in due course from the Conference Secretary, 10, Parks Road, Oxford. (See entry above, under Oxford, 1936.)

ABERYSTWYTH, 1937.

The Joint Secretaries of the Fourth International Grassland Congress (Mr. William Davies and Dr. R. O. Whyte) hope to be in a position to distribute a brochure containing further details of the plans for the Congress and an application form in October next. It would facilitate arrangements if persons wishing to participate in one of the four options outlined in the Preliminary Notice would signify their intentions at the earliest possible date. All persons who have already written to the organizers will receive the brochure and subsequent information automatically. Further copies of the Preliminary Notice and any other details are available on request to the Joint Secretaries, Agricultural Buildings, Aberystwyth, Great Britain.

The Chief Officer will be glad to receive notices of forthcoming Conferences for insertion in this section of *Herbage Reviews*; also reports of Conferences as soon as available, for reviewing in these columns and in *Herbage Abstracts*.

ANNOTATIONS

GREAT BRITAIN. (410)

Bulletin on the Production of Seed of Herbage and Forage Crops.

Work is still proceeding on the preparation of this Bulletin. A considerable number of replies to the questionnaires and some of the articles are now in the hands of the Chief Officer; it would be a great help if persons desiring to contribute in any way to the Bulletin, and who have not already written to the Herbage Bureau, would do so at an early date in order that the editors of the Bulletin may have a clear idea of its size and scope.

Publications of the Welsh Plant Breeding Station, Aberystwyth.

The Bulletins and other publications of the Welsh Plant Breeding Station, under the direction of Professor R. G. Stapledon, are of direct interest to all concerned with grassland research. Any person wishing to be kept advised regarding these publications should write to the Secretary, Welsh Plant Breeding Station, Aberystwyth, who will arrange for the dispatch of notices giving contents, publication date and price of all future issues.

SWEDEN. (485)

Report from Luleå, Norrland.

The report on the work of the Institute for Agricultural Chemistry and Plant Biology and of the Seed Testing Institute at Luleå, Norrland, Sweden, in 1935, by A. Ulander, E. Hannerz and L. S. Agerberg, was published at Luleå in 1936. [Ruuths Boktryckeri.]

Sections deal with the Institute's local manurial and liming trials, and variety trials; Sunderby Experimental Farm; Alträsk Experimental Farm; Hagalund Experiment Field; and Gran and Matarengi Experimental Stations.

An article by Mr. Lars E. Agerberg, entitled "Some observations on the depth of the snow cover and of the frozen layer of earth and the influence of these factors on the yield of meadows," is included.

Finally a brief account is given of the investigations conducted at the North Bothnia Seed Testing Station. It is stated that during the autumn and early winter some investigations were conducted regarding germination in *Agrostis canina*. This species has been found to have a very long after-ripening period. The investigations showed that by the use of alternating temperatures very high germination figures can be attained to for *A. canina* seed—this applies to seed set to germinate as late as the month of May. In some cases alternating temperatures had no effect. By drying of the seed at 25–30° C. for some few days it can, however, be made germination-ripe. Seed which had not been dried showed a germination of only approximately 40 per cent after four weeks, while the germination of that which had been dried previously was 98–99 per cent; in a few days 90 per cent of the seeds had germinated. The Institute intends to continue these experiments.

SWITZERLAND. **(494)**

Professor George Wiegner.

Appreciations have appeared in several journals of the life and work of the late Professor George Wiegner, who died on April 14, 1936. Dr. Wiegner was well known to grassland workers for his work as Director of the Laboratory for Agricultural Chemistry and of the Institute for Animal Nutrition of the Agricultural College, Zürich, and as Chairman of the Fourth Section of the Third International Grassland Congress held at Zürich in 1934.

ALGERIA. **(65)**

Report from Seed Testing and Plant Breeding Station.

The advisory work of the station has increased, the number of enquiries dealt with during the year under review amounting to 1,048.

One hundred and seventeen lots, or 29,600 kg. of seed of lucerne, *Trifolium alexandrinum*, etc., have been examined for *Cuscuta* content.

Plant breeding has been concerned entirely with cereals.

Publications by members of staff include observations on the vernalization of seed. (From Report, by L. Ducellier, of the work of the Agricultural Laboratory and the Seed Testing and Plant Breeding Station, published 1936, pp. 3).

CANADA. **(71)**

Professor W. J. Squirrell.

Professor William J. Squirrell, head of the Department of Field Husbandry of the Ontario Agricultural College, was fatally injured in an automobile accident near Smithville, Ontario, on July 25. Professor Squirrell was responsible for the development of many new varieties of grains and was for many years Secretary of the Ontario Agricultural and Experimental Union. (From *J. Amer. Soc. Agron.* 28. 686. 1936.)

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